It will be taken for granted, that up to the present, the simple dike with chambers the best means for raising ships, since its safe and simple working secures to the the first place when compared with all the other arrangements for raising ships already ed or existing ouly in a state of experiments. — Such dikes have only one great antage, which consists in the fact that they require for their good working conside- uantities of water supplied by the top container and that therefore the application se dikes is restricted to localities, where great watersupply is at hand. This drawback especially with highly situated summit - containers, be considered as an obstacle ible to overcome, thus compelling the architect to construct other mechanical appa- or raising the ships, whereby economies in water can be made; — for the pumping the required working water would be very expensive and could only be effected at all scale.

A second, but far less important disadvantage of the simple dike with chamber ts in the fact that the watersupply as well as the getting rid of it can only be effecte slowly. The supply channels and the lock-gates must be of small dimensions on nt of the lock-arrangements; thus at the sides of the containers only two supply s are arranged which concentrate the course of water only to two spots so that, as said, the filling of the chamber is effected very slowly; in the longitudinal direction s only one waterflow possible; both these circumstances are very inconvenient. In to avoid these disavantages, many constructions of the circulation passages have been d, which are more or less supposed to improve the conditions.

The patented Apparatus fer Varying the Water Level in Lock-basins System rný, has for its object to meet the said disadvantages, but also to maintain all the -known benefits of the simple dike with chambers by providing a simplified and omical means for raising and lowering vessels with a minimum expenditure of water mechanical power.

As may be gathered from the main sketch figure 5, the improved apparatus consists lled containers „A“, inside each of which a cylinder is caused to rotate round its „O“, one segment „F“ of the circle being removed. The extremely simple working of apparatus is obvious: In the position of „A“, the empty segment „F“ being at the m and the remaining part of the cylinder being in contact with the surface of the r, the latter is at one and the same level with that of the bottom container. If now apacity of the segment „F“ be equal to that of the remaining space of the cylinder h is empty, when the latter takes up the position „C“ the water must reach the highest , after the cylinder has completed a revolution through an angle of 180⁰, that is to say, ust be on the same level with that of the top container. The water surface is of course ming the position „B“ after the cylinder has only completed a revolution through an of 90⁰.

If we now imagine the space shewn by dotted lines to be the chamber of the ship, fice „C“ to be the outles into the upper container and the orifice „D“ to be that into ttom container, the whole principle of the new arrangement is evindently made clear.

In applying this principle, both the problems are solved, the chambre hip being fully identical with a dike with chambers, with the sole difference h that for filling it, no extra water will be required since by moving the water to a t serves as the means for floating and raising ships, and secondly since the of the water and its exit are effected along the length of the ship's chamber and quently the speed of lifting will not be restricted and a stream of the water disturb quietness of the ship cannot incur; this latter fact is the less possible, as the water akes always place below the low level of the water. Concerning the required w pacity we shall speak later on.

For reasons of construction character, the cylinder for displacing the water be made of one and the same piece, it must be composed of several parts, the r of which is dependent on the width of the cylinder and this width must be re according to the load upon its axles and to the maximum of the buoyancy of the Between the several cylinders for displacing the water intermediate partition walls foundation are necessary for the bearings of the cylinder axles so that the power of bu may be transmitted from these axles to the walls. Said intermediate partition wa joined together by a wall „E“ (see fig. 5.), in which passages „m“ of sufficient dime must be cut out below the level of the bottom container in order that on the one the partition walls are made stable and on the other hand in order to prevent the from coming into contact with said cylinders. Thus the real arrangement of the app for raising ships — as shewn in the drawings fig. 6, 7, and 8. — is already made

The length of the chamber „L“ is adopted for sake of making the radius cylinder for displacing the water as small as possible — to correspond to the whole the cylinder. The latter length must be chosen according to requirement and w different in each case, but always in accordance with the view of taking the gate consideration. The number of the displacing cylinders is found by a preliminary calcu whereby the limit of their width and the required thickness of the partition walls m taken into consideration.

For such calculation the following two principles must be upheld:

1. The previously ascertained height of lifting the ships — called „H“ mu equal to the diameter of the circle drawn tangentially to the chord of the segment of the

2. The whole space of the segments must be equal to the space for the water is displaced, that is to say, the space of the segments must be of the capacity of the chamber added to that of the spaces between the displacing cylinders and the walls.

In reference with the calculation we call:

The number of displacing cylinders . . . . = n
The width of the pit . . . . = b_1
The width of the displacing cylinder . . . . = b
The width of a joint in the walls . . . . = b_2
The thickness of a partition wall . . . . = c
The radius of a displacing cylinder . . . . = R
The area of a segment of the circle . . . . = F
The required breadth of the ship's chamber . . . . = k
its previously ascertained length . . . . = B

The length of this chamber increased on account of one gate . $= B_1$
The length of this chamber increased on account of two gates $= B_2$
The length of lifting corresponding to them . . . $H_1 + H_2 = H$
and the corresponding capacity . . . . $K_1 + K_2 = K$

Now according to figure 6 we draw up the equations as follows:

$$\lesssim b_1 = L - (n - 1)\, c$$

$$\lesssim b_2 = 2\, n\, b_2$$

$$\lesssim b = \lesssim b_1 - \lesssim b_2 = L - (n - 1)\, c - 2\, n\, b_2$$

ncerning the capacity of the ship's chamber: $K = K_1 + K_2 = (H_1\, B_1 + H_2\, B_2)\, k$

According to the second principle above:

$$F . \lesssim b_1 = K + \lesssim b_1 . b_2 . 2\, H + \lesssim b_2\, (\pi\, R^2 - F)$$

n which equation the second part signifies the play found on the periphery — and the hird part stands for the joints between the displacing cylinders and the walls.

$$F\, (\lesssim b_1 + \lesssim b_2) = K + 2\, b_2 \lesssim b_1 . H + \lesssim b_2 . \pi\, R^2.$$

The area „F" is found from „H" and „R" in the following equation:

$$F = \pi\, R^2\, \frac{\alpha}{180} - \frac{H}{2} \sqrt{R^2 - \left(\frac{H}{2}\right)^2},$$

herein „α" means half of the angle corresponding to the segment — it is found by:

$$\cos \alpha = \frac{H}{2\, R}$$

e displacing cylinder being immersed into the water during its revolution, displaces water capacity or volume of which is equal to the capacity of the immersed part of the ylinder, thus said water is raised aud expelled into the empty spaces of the ship's chamber nd into those of the joints. After completion of the displacement, the area of the water hus displaced is equal to that of half the ring of the circles having the radii „$\frac{H}{2}$" and „R", hat is to say:

$$\frac{\pi}{2} \left(R^2 - \left(\frac{H}{2}\right)^2\right)$$

This displacement takes place fully proportional to the angle of revolution. The uantity of the expelled water is equal to the said area multiplied by $\lesssim b$, we have therefore:

$$\frac{\pi}{2} \left(R^2 - \left(\frac{H}{2}\right)^2\right) \lesssim b.$$

For calculating the moments deriving from the power of buoyancy, it is necess ivide the whole revolution into a convenient number „m“ of phases; each of th ases is to correspond with the equivalent part of the expelled water:

$$\frac{\pi}{2\,m}\left(R^{2}-\left(\frac{H}{2}\right)^{2}\right)\lessgtr b.$$

In Figure 1. „m“ is supposed to be 12 and the separate lengths of the displac inders and their immersed areas respectively are indicated accordingly.

In case the water lewel raises by „h“ and if we call „c“ the respective horizo nean lengths of the areas of the parts which are not immersed during this phase and he lengths of those areas which are more immersed during the same phase — both p rom one another at the circle of the radius „$\frac{H}{2}$“, we have:

$$\frac{\pi \lessgtr b}{2.\ m}\left(R^{2}-\left(\frac{H}{2}\right)^{2}\right)=h\,(k.\,B+\lessgtr b_{1}\,.\,c+\lessgtr b_{2}\,.\,d.)$$

From this equation for the several phases may be gathered the increasing levels „ of the water and the average areas of the exits (the latter between the brackets).

The immersed areas of the displacing cylinders consist each of the really submerge areas and of the area which is more immersed through the raised level of the water, th latter being easily ascertained or calculated from the drawing and the thus increased capacit of the expelled water during this phase must be equal to the immersed area, ascertain as said before and multiplied by $\lessgtr$ b.

We indicate this capacity by m^3 and the same is just the power of buoyancy he water equal to = $P\alpha$ expressed in tons.

This power works at the centre of gravity of the capacity and therefore at t of the area also; if we ascertain the ordinates of this centre, we are easily capable of c culating the moments of revolution working the displacing cylinders, for, if we indicate t horizontal ordinate in question by $x\alpha$ the said moment would be = $P\alpha\ x\alpha$.

In order to determine the ordinates of the centre of gravity, the centres of of the impressed areas e_1 e_2 e_3 etc., and those of the more immersed areas f_1 f_2 f_3 must be ascertained and by doing so, we obtain according to the well known equatio

$$x=\frac{\lessgtr m.\,x}{\lessgtr m}\qquad\qquad y=\frac{\lessgtr m.\,y}{\lessgtr m}$$

the ordinates of centres of gravity of the whole immersed areas of the displacing cylinders These centres represent — as shown in fig. 1, when joined together, so called gravity-curves

These moments of the power of buoyancy are balanced by the moments of the mas itself. The capacity of this mass must be ascertained from the construction and also, th centre of gravity is to be determined for the position 0. Since this centre is moving alon the periphery of a circle, its moment for an angle of revolution „α“ would be:

$$M_{Q\alpha}=Q\,q.\,\sin\alpha.$$

and the moments thus us resulting:

$$P_{\alpha.}\,x_{\alpha}-Q\,q.\,\sin\alpha$$

may be expressed by diagram, where they represent a curve very similar to the sine-curve, but being of greater steepness in its first part (see fig. 11). To work with these moments by making use of our ordinary mechanical means is almost impossible; the expenses of work would become enormous, although the whole arrangement would be lacking ef efficiency. They may, however, be partly balanced by a counter-weight placed inside the displacing cylinder thus obtaining far reaching results. If namely a counter-weight (Fig. 1.) is placed into the vertex of the displacing body, its moment can be represented by diagram, it will be : — $Z_1\ z_1 . \sin \alpha$, than that of the sine-curve presuming »Z_1“ the weight itself which in each case can be ascertained from a sine-curve not greatly differing from that given above $P x - P q . \sin \alpha$, the centre of gravity of this weight being apart from the centre „z_1“ — the diagram of the resulting moments will show in the first part of the whole curve — a positive one, and in the second part a negative one. The moments are then:

$$P x - Q q \sin \alpha - Z_1\ z_1 \sin \alpha = P x - (Q q + Z_1\ z_1) \sin \alpha$$

which when compared with the original moments are somewhat greatly reduced.

This counterweight may consist of cast-iron blocks, but much less expensive vould be a balast of water, that is to say, if a space in the shape of a segment fully symetrical to the segment „F“ is formed at the vertex of the displacing body and compleely filled up with water. In each special case the dimensions of said space are calculated y the equation $M_1 = Z_1\ z_1$ — thus if its area be called „f“ and its lever „z_1“, we have:

$$M_1 = f. \lessgtr b. z_1 \quad . \ . \ . \ . \ . \ . \quad f z_1 = \frac{M_1}{\lessgtr b}$$

nd if the body or space in question forms a segment:

$$f z_1 = \frac{M_1}{\lessgtr b} = \left(\pi R^2 \ \frac{\gamma}{180}\right) \left(\frac{2}{3}\ R. \ \frac{\sin \gamma}{\operatorname{arc} \gamma}\right) - \left(R^2 \sin \gamma \cos \gamma\right) \left(\frac{2}{3}\ R. \cos \gamma\right)$$

hereby „γ“ is equal to half the angle corresponding to the segment. Experimentally this ngle „γ“ may be calculated out of this equation.

The moments thus resulting may be further more reduced, by displacing the same respect of their effects. This is done by a second — somewhat smaller — countereight, which takes the lead of a right angle in the direction of lifting, in advance of the gger counterweight. Its greatest moment M_2 therefore oceurs in the original and end potions of the displacing body. It now the maximum of the moment resulting first in the sition when the angle „α“ $= M_3$, M_2 may be ascertained by an equation, in which the d — moments in the 0 position and in that of the angle „α“ appear to be equal:

$$M_2 = M_3 - M_2 . \sin \alpha \qquad M_2 = \frac{M_3}{1 + \sin \alpha}$$

Assuming again the waterbalast, the area and the working lever ot the same may ascertained in the manner said of the first counterweight, so that:

$$M_2 = Z_2 . z_2$$

Now we feel compelled to speak also of the third counterweight, the object of ich is to reduce the power of buoyancy working upon the axle to a minimum, without aving any influence on the motion and on the working moments of the powers in ques second condition forces us to place this weight which also consists of a water completely central position round the axle.

In the upper water level, the power working upon the axle is equal to the weight of the expelled water minus the own weight of the displacer and minus that of the counterweights. The said working power, however, works in the bottom waterlevel in the reversed direction and is here only equal to the own weight of the displacer more the weights of all counterweights. If we wish now to establish the possibly best balance, we are compelled to consider also the third weight „Z_3“ by equatising both the powers, or when put in equation form:

$$P_{max} - (Q + Z_1 + Z_2) - Z_3 = (Q + Z_1 + Z_2) + Z_3$$

$$Z_3 = \frac{P}{2} - (Q + Z_1 + Z_2)$$

thus reducing the load upon the axle to its half $p = \frac{P}{2}$.

This force or load „p“ represents the charge upon all parts of the structure an serves as basis for calculating the dimensions of the latter.

The displacing bodies are water proof metal vessels (Fig.: 1.) constructed in a shape found by calculation, and stiffened in their interior by a sufficient number of lattice - work girders „C“ being placed in the radial direction and rivetted to the rosette „B“ (see fig.: 2). The fields thus formed are further stiffened by radially placed angle-irons „D“ and other such irons „E“ centrally arranged. The empty space of the segment is not covered by metal plates but only constructed as lattice - work, thus only completing the circle for better arranging the driving means.

Axle „O“ is either constructed as a solid body of steel — as it is shewn in the drawings — or it is preferably made like a rivetted girder of much larger diameter and bearing strength. Upon this axle which remains stationary, turns the boss of the rosette „B“ with the whole displacing body. In order to prevent the elements of the structure from oxidising or rusting the contact areas are provided with inlaid bronze dishes „G“. The number of the latter depends on the width of the displacing body „b“, so that on narrow bodies (Fig.: 12., 14.) two such dishes are made use of, whilst with longer bodies a third dish is provided in the centre (Fig.: 2 and 13.)

It has already been mentioned, that the whole power of buoyancy in each displacing body must be taken up by the partition walls. It will therefore be necessary to mak the latter strong enough as regards the capacity, which is calculated by supposing t [illegible] — block m³ to be circa 20 t, thus:

$$C = \frac{p}{n} : 20$$

Moreover the foundation of the walls must be armed at the top and bottom b sufficiently strong girders, which are kept embracing the walls, by sufficiently strong tightening screws fixed to the foundation. These screws must be placed as near as possibl and concentrically to the axle.

On the several drawings, the top girders, supporting the axles are indicated by „M“ and the bottom girders by „N“. The connecting screws „Q“ are arranged, as it is shew in Fig.: 2. These screws have a sufficiently strong plate „S“ of cast - steel, between th top girders and their nuts, with the object of transmitting the effect of the forces upon th axle, directly to the screws. The axle on the other hand is attached to the top girders „M by means of an other cast - steel plate „T“ screwed to the girder or rivetted to it; th boss „g“ of said plate receiving the gudgeons of the axle „i“ in a solid manner. The plate correspond as far as possible with the profil of the girder, are provided at thei and bottom with flanges so that they may easily be screwed to the girder, a plate „S“ against which said boss is proped by means of strong ribs at the top a

In the central part of the foundation, that is to say, above the axle, a sort of man hole or shaft „U“ is provided within the wall, through which workmen may reach the op girder so that it is rendered possible to inspect any spot of the outer surface, when the displacing body revolves, and also to repair any part thereof, if required. For this purose it will also be necessary to provide means for allowing the displacing body to compte the whole revolution round its axis. During the lift of a ship, the man-holes would e filled up with water, so that injurious complications are created; in order to obviate the latter, it will be necessary to render the man-holes waterproof and this is effected by employing cast-plates „C“ (see Fig.: 2.) which are pressed by means of chains and louble nuts to the edges of the partition wall, which are provided with wooden borders „m“. By this means they are made waterproof and their walls are capable of being dismantled if repair or inspection requires it.

The interior of the displacing bodies is accessible by other water proof manles, which are best arranged in the chord of the segment at a suitable spot. Inside the odies a system of steps is provided so that the whole inner surface may be accessible in ll its points. For the supply of the balast-casings with water and for emptying the ame, they are provided on the one hand with appropriate pipings capable of being shut nd on the other hand with man-holes for their inspection.

There are only very few portions of the parts liable to friction, that is to say, the ronze-dishes in the axle-bearings, which however may be lubricated from inside, he oilboxes for this purpose being either placed directly at the boss — where they are nly accessible after emptying the balast „Z_3“ or the lubrication takes place by means of ipes provided at the outside of the casing, so that oiling is always possible.

The displacing bodies are set in motion either by wire-ropes wound round them r by tooth-gear at their periphery engaging the driving gear in a direct way. The rst mentioned means being more convenient, we will adopt it for this treatise thorough. ach displacing body is therefore provided in the centre of its width with a groove formed y an U-iron „n“ (see fiig. 1, 2, 3) for the remption of the driving rope. The toppe is placed from below the drum „V“ to the upper part of the periphery of the body nd then follows to the bottom part, where it is fastened to it at „a“ (see fig. 1); the ottom rope is drawn in the reversed direction and follows from the top of the drum rough apertures of the wall to the bottom periphery of the displacing body, being fastened „b“, so that a complete revolution of said body is rendered possible — this being nessary, as said before, for allowing inspection of the outer side of the displacing body ong its whole periphery.

Fastening of the ropes to the bodies is best effected by means of adjustingrews (see fig. 4), thus rendering equalizing of the strain of the ropes faisible, a considerable nsion of the latter being unavoidable particularly at the start of work. The rope is wound on the drum as often as required by the total length of it when unwound and is fasned on the drum in the normal manner.

Since the ropes are always partly immersed in water, it is advisable to make the me of zinked wire and without any hamp-filling; thus preventing moisture to remain side and the ropes from oxidising or rusting. During work these ropes must of course provided with a good lubrication.

Each displacing body has its own crane (fig. 3) consisting of the shaft „B“, the othed wheel „D“ and the drum „V“. All the shafts of the different cranes are situated one straigth line and parallel to them, runs the driving shaft „E“ provided with the all toothed wheels „d“ corresponding to the bigger teeth of the drum wheel „D“. Said re either directly engaged with one another — as it is the case when higher ing the ship is required, or some transmitting gear may be inserted between the two in order to effect the raising more slowly. The whole arrangement of the cranes rest in bearings of the frames „A“, which are attached to the foundation by screws.

If transmitting gear is employed, it is attached to the wall adjoining the displacin chamber in question and in such case it will be best to place the motor in the centre.

The driving power to be used does not matter, the system „Pokorný“ allows a suitable force to be employed. If waterpower is completely lacking, steam engines ma be used — as for instance in isolated plants, or electrical means may be used, which is mainl the case when several steps for raising ships are introduced one aside the other, the electri power being then generated in a common central station. If however, water power is a hand, it may be of great advantage to make also use of it for driving all the accessor plants. The details of the calculation and the working capacity of the new system will b much more clearly exposed by solving the following problems dealing with the matt in question:

I. An Apparatus

for Varying the Water-level in lock-basins

to be calculated for raising ships of 65·0 meter full length, 8·2 meter breadth, 1·8 meter immersion be lifted to a height of 12·0 meter.

From this problem we ascertain as follows:

$B = 66{\cdot}0$ m.; $k = 8{\cdot}8$ m.; $H = 12{\cdot}0$ m.; $H_1 = H - t = 9{\cdot}5$

$H_2 = 2{\cdot}5$ m.

As shewn in the plan of figure 6:

$L = 71.22$ m, $B_1 = 70.1$ m, $B_2 = 71.2$ m.

From a aliminary calculation concerning the load upon the axle, the number displacing bodies amounts to $n = 12$ and the required breadth of the foundation $c = 1{\cdot}5$

Supposing the width of the joints $b_2 = 0{\cdot}07$ m, it follows:

$$\Sigma b_2 = 2 \times 12 \times 0{\cdot}07 \text{ m.} = 1{\cdot}68 \text{ m.}$$
$$\Sigma b_1 = 71{\cdot}22 - (11 \times 1{\cdot}5) = 54{\cdot}72 \text{ „}$$
$$\Sigma b = 54{\cdot}72 - 1{\cdot}68 = 53{\cdot}04 \text{ „}$$
$$b = 53{\cdot}04 : 12 = 4{\cdot}42 \text{ „}$$

The capacity of the ship's chamber is:

$$K = (8{\cdot}8 \times 12{\cdot}0 \times 70{\cdot}1) + (2{\cdot}5 \times 8{\cdot}8 \times 1{\cdot}1) = 7426{\cdot}36 \text{ m}^3$$

The area of this chamber in the bottom part of H_1 in height:

$$k\,B_1 = 8{\cdot}8 \times 70{\cdot}1 = 616{\cdot}88 \text{ m}^2$$

and in the top part: $k\,B_2 = 8{\cdot}8 \times 71{\cdot}2 = 626{\cdot}6 \text{ m}^2$

For calculating the radii of the displacing bodies we insert into the equation the different values:

$$56{\cdot}4\ F = 7426{\cdot}76 + (0{\cdot}14 \times 54{\cdot}72 \times 12{\cdot}0) + 1{\cdot}68\ \pi\ R^2$$

$$56{\cdot}4\ F = 7518{\cdot}69 + 1{\cdot}68\ \pi\ R^2.$$

By experimentally inserting the different lengths of „R“ we find the real radius as folows:

$$R = 14{\cdot}22\ \text{m}; \qquad R^2 = 202{\cdot}21; \qquad \pi\ R^2 = 635{\cdot}238\ \text{m}^2$$

and from the equation $F = 152{\cdot}2\ \text{m}^2$

rom the second one: $F = 229{\cdot}7 - 77{\cdot}3 = 152{\cdot}4\ \text{m}^2$ $\qquad \alpha = 65{\cdot}1^0$

Therefore it follows for the area of the displacing body:

$$\pi\ R^2 - F = 635{\cdot}24 - 152{\cdot}4 = 482{\cdot}84\ \text{m}^2$$

the whole area of displacement being:

$$\frac{\pi}{2}\left(R^2 - \left(\frac{H}{2}\right)^2\right) = \frac{\pi}{2}\ 166{\cdot}21 = 261{\cdot}08\ \text{m}^2$$

the capacity of the expelled water is:

$$261{\cdot}08 \times 53{\cdot}08 = 13.847{\cdot}68\ \text{m}^3$$

In order to calculate the moments each time working in the apparatus, we divide he whole revolution into 12 phases — the diplacing body in Fig.: 1 is drawing at the cale of 1 : 100 — so that to each phase may be correspondent

an area $e = 261{\cdot}08 : 12 = 21{\cdot}756\ \text{m}^2$

and the capacity $13.847{\cdot}68 : 12 = 1154{\cdot}0\ \text{m}^3$

The value of „c“ and „d“, required for the calculation can be gathered from the rawing, for the first phase we find:

$$1154{\cdot}0 = h_1 \left\{ 616{\cdot}9 + (54{\cdot}72 \times 11{\cdot}1) + (1{\cdot}68 \times 15{\cdot}3) \right\}$$

The figures between the brackets indicate the average of the outlet area at each eriod of time and this area must be divided into the expelled mass = 1154·0, in order to nd the difference of the varying level of the water during this phase. Here it is:

$$h_1 = 1154{\cdot}0 : 1249{\cdot}8 = 0{\cdot}923\ \text{m}.$$

This calculation must be performed for each phase and it must of course the final ifference of the water level at the end of the 12th phase be equal to the previously determined total height „H“ for raising the ship.

The anexed table I gives for all the phases the value of „c“ and „d“, that of the outlet area, and the differences of the varying level in each phase and also the e water at the end of each phase.

During the 9th phase, the water has a depth of 9·108 m, — it must therefore only rise 0·392 m in order to reach the level of the chamber of the ship or in other words the level of the bottom of the top container; — this rise being effected during the 10th phase. But the latter must now be performed in the reverse direction so that the still required mass of water:

$$0{\cdot}392 \left\{ 616{\cdot}9 + (54{\cdot}44 \times 9{\cdot}0) + (1{\cdot}68 \times 19{\cdot}0) \right\} =$$
$$= 0{\cdot}392 \times 1141{\cdot}3 = 448{\cdot}5 \text{ m}^3$$

is to be deducted from the watermass corresponding to a whole phase and this mass remains then for the next rise; the further calculation for the outlet area and the following rise is done in the manner as before, taking the remaining water mass into account, as follows:

$$1154 - 448{\cdot}5 = 705{\cdot}5 \text{ m}^3$$
$$705{\cdot}5 = h \left\{ 626{\cdot}6 + (54{\cdot}72 \times 9{\cdot}2) + (1.68 \times 18{\cdot}4) \right\}$$
$$h = 705{\cdot}5 : 1160{\cdot}9 = 0{\cdot}609 \text{ m.}$$

After all the phases have been calculated in the same manner, we can now start with ascertaining the immersed areas or surfaces of the displacing bodies: the first part of the area „e“ is the same for each phase, the second part of the area must be calculated with reference to the drawing wherein the different levels of the watersurface are indicated. These immersed areas thus calculated and found must be multiplied by $\lesssim b = 53{\cdot}04$ in order to find the capacity of the expelled watter, expressed in metercube (m^3) an this capacity is equal to the power „P“ expressed in tons, which works in the apparatus. Table I shows also these values.

The calculation of the lever arms — represented by the ordinates „x“ may b detected from the annexed table IX.

If the powers — thus ascertained — are multiplied by the length of the arms, w find the moments working at the end of each phase, and these moments are also give in the table I.

The own weight of the structure must be calculated with reference to the drawings I have found this weight to be 191.650 kg for each displacing body or 2.300 t for th whole plant. The figures found in the last column of table I indicate the results of my calculation as regards the different value of:

$$Px - Qq \sin \alpha$$

This weigth must be overcome by the driving engine without considering the counterweights

The moment of the required first counterweight is ascertained as the balance between the 3rd and the 9th phase:

$$(26.877{\cdot}3 + 17{\cdot}728{\cdot}0)\ {}^1\!/_2 = Z_1 \,.\, z_1 \,.\, \sin 45^0 = 22.306{\cdot}6 \text{ tm.}$$

so that:

$$Z_1 z_1 = 31.540{\cdot}0 \text{ tm.}$$

The moments of the other phases are easily found by the multiplication with th sinus of the angle in question; their value may be seen in table II wherein also th remaining moments after their reduction are indicated, according to:

$$Px - Qq \sin \alpha - Z_1 z_1 \sin \alpha = Px - (Qq + Z_1 z_1) \sin \alpha$$

It may be observed that the maximum moment of 31.904·8 tm is here enormously educed to 4.578·0 tm.

Supposing now this counterweight assumes the shape of segment and is a container full of water, its size is ascertained as follows: If we make

$$f z_1 = \frac{M_1}{\lessgtr b} = 31.540{\cdot}0 : 53{\cdot}04 = 594{\cdot}6$$

and take $\gamma = 42^0\ 10'$ it is:

$$f z_1 = (150{\cdot}57 \times 8{\cdot}627) - (100{\cdot}765 \times 6{\cdot}97) = 596{\cdot}75$$

$$f = 150{\cdot}57 - 100{\cdot}765 = 49{\cdot}805 \text{ m}^2$$

$$z_1 = 596{\cdot}75 : 49{\cdot}805 = 11{\cdot}98 \text{ m.}$$

Finally its weight is: $Z_1 = f. \lessgtr b = 49{\cdot}805 \times 53{\cdot}04 = 2641{\cdot}7$ t

We come now to the second counterweight, which is ascertained by supposing a balance of the moments in the position 0 and in the 12th, 3rd and 9th phase, that is to say:

$$M_2 = 4575 : (1 + \sin 45^0) = 4575 : 1{\cdot}70711 = 2680{\cdot}0 \text{ tm.}$$

in the 0 position out of which the other phases are calculated and put up in the table II.

If we assume this counterweight to take the shape of a square or to be a cube illed with water, we have:

$$f z_2 = 2680{\cdot}0 : 53{\cdot}04 = 52{\cdot}24$$

$$f = 1{\cdot}64 \times 2{\cdot}38 = 3{\cdot}9032 \text{ m}^2; \qquad z_2 = 13{\cdot}40 \text{ m}$$

nd its weight: $Z_2 = f. \lessgtr b = 3{\cdot}9 \times 53{\cdot}04 = 200{\cdot}0$ t.

The driving engine must overcome all the moments remaining after these end-moents have been deducted so that the maximum of the moment 2.708·0 tm. is the only one hich forms the basis for all the calculations corcerning the driving mechanism.

For the sake of better observation the diagram in Fig. 11 illustrates all the curves moments in question.

The third counterweight serving for equalising the load upon the axles is ascertained follows:

$$Z_3 = \frac{P}{2} - (Q + Z_1 + Z_2)$$

$$P = (\pi R^2 - F)\ b.\ 1000 \text{ kg} = 482{\cdot}84 \times 4420 = 2{,}134.150 \text{ kg}$$

$$p = \frac{P}{2} = \qquad 1{,}067.075 \text{ ,,}$$

$$\frac{Q}{12} = 2{,}300.000 : 12 = 191.667 \text{ kg}$$

The axle and the boss = 30.408 ,,

$\qquad\qquad\qquad\qquad\qquad\qquad$ 222.075 ,,

The counterweights $Z_1 = 2641{\cdot}7$ t

$Z_2 = 200{\cdot}0$

$2841{\cdot}7 : 12 = \qquad 236.800$,,

$Z_3 = \qquad 610.200$ kg.

Assuming the height of the third counterweight = H, the same of the whole apparatus, the second dimension of its front surface is:

$$l = 610{\cdot}2 : (H \times b) = 610{\cdot}2 : 53{\cdot}04 = 11{\cdot}50 \text{ m.}$$

It is obvious, that this counterweight „Z_3“ can as well be joined with that „Z_1“ to a whole, but as this does not influence my system, I shall not unite them.

The most important elements of the structure are calculated as follows:

The axle of the displacer will be charged in its metal-enclosures with the reduced power „p« of buoyancy. In calculating this element we assume that the central enclosure is charged by

$\frac{p}{2}$ and each lateral enclosure by $\frac{p}{4}$ following the equation:

$$M = \frac{p}{4} \frac{(a a' + 2 b b' + c c')}{l} = \frac{p}{2} \frac{a a' + b b'}{l}$$

$$= 533.540 \frac{(320 \times 4140) + (2230 \times 2230)}{4460} = 753{,}358.480$$

$$d^3 = \frac{32 M}{\pi k} = \frac{32 \times 753{,}358.480}{3{\cdot}1415 \quad 10 \text{ kg}} = 770{,}000.000 \qquad d = 918 \text{ m/m.}$$

assuming the material as steel and k = 10 kg, that is to say, calculating with an insurance or safety 15 times as large as the original safety.

The gudgeons of the axle are loaded by $\frac{p}{2}$ therefore:

$$\frac{\pi d^2}{4} = \frac{p}{2} \cdot \frac{1}{k} = \frac{1{,}067.075}{20} = 53.353{\cdot}8 \qquad d = 261 \text{ m/m.}$$

The foundation must be strong enough to overcome „p“, its capacity mus therefore be:

1,067.075 : 2000 . . . . . . = 533·5 m³
20 % added for safety . . . = 106·7 „
total . . . . = 640·2 m³

Since the partition walls have an area

$$1{\cdot}5 \text{ m} \times (7 + 14{\cdot}0) = 30.5 \text{ m}^2$$

it will be necessary to let the bordering girders a length of: 640·2 : 30·5 = 21·0

The girders will be of the whole breadth as the wall: B = 1500 m/m and the other dimensions are obtained from the well known equation:

$$\frac{p\ l.}{8 K} = \frac{B H^3 - b h^3}{6 H}$$

Assuming the total height of both the vertical metal walls B — b = 60 m/m we find b = 1440 m/m, and if we introduce now h = 0·95 H, we fin

$$\frac{p\ l}{8 k} = 44{\cdot}23 H^2$$

If we consider the steel sheets also with a safety of 15 times the original strength, hat is to say $k = 10$ kg, we obtain pr ***the bottom girders*** when:

$$l = 21.000\ ^{m}/_{m}: \qquad H = 2520\ ^{m}/_{m}, \qquad \frac{H - h}{2} = 63\ ^{m}/_{m}$$

nd for ***the top girders*** if:

$$l = 10.000\ ^{m}/_{m}: \qquad H = 1740\ ^{m}/_{m}, \qquad \frac{H - h}{2} = 44\ ^{m}/_{m}.$$

Tthe Tightening screws are also charged in each partition wall by the load „p“; ssuming as before $k = 10$ kg, the total cross-section of the same:

$$f = \frac{p}{k} = 106.707{\cdot}5\ ^{m}/_{m}{}^{2}.$$

Supposing now in the proximity of the shaft (fig. 2):

2 rows of 6 screws $d = 100\ ^{m}/_{m}$ $f = 7854 \times 12 = 94.248\ ^{m}/_{m}{}^{2}$
2 „ „ 4 „ $d = 50$ „ $f = 1963 \times 8 = 15.704$ „
total $109.952\ ^{m}/_{m}{}^{2}$

y which result the whole strain will be met.

The height of the girders is decreasing towards their ends, and cast steel plates re employed as securing means on the top girder and underneath the bottom girder, serving as supports for the nuts or screws-heads respectively. The whole structure may e gathered in fig. 2.

The wire ropes must be strong enough to overcome the maximum moment of 708·3 tm., thus the power of a rope must be:

$$2,708.300 : 14{\cdot}22 = 190{\cdot}500 \text{ kg}$$

nd therefore for 12 ropes (one for each displacer) the power corresponds to 15.875 kg per ope. The steel wire ropes of a transverse strength of 150 kg — taking a tenfold safety s they run in water must have a cross section as regards the metal parts of one rope:

$f = 15.875 : 15$ . . . . $= 1060\ ^{m}/_{m}{}^{2}$
with an addition of 10% on account of its twisting $= 106$ „
total of . . . . $= 1166\ ^{m}/_{m}{}^{2}$

hat is to say the diameter must be $d = 38{\cdot}6\ ^{m}/_{m}$.

The strength or power of the driving engine depends upon the maximum oment (calculated as above) to be overcome and of the required working capacity of the pparatus. This capacity can easily be determined by the engine builder since he is the erson who chooses the speed of the displacers and therefore also the speed by which the hip is to be raised. But on account of a smooth operation in lifting ships, it will be advisable to determine a maximum raising speed. In order to better judge of this question shall solve two different problems — first for a daily work of raising 60 ships, as it is ired up to date and secondly for an average speed of raising ships of 100 $^{m}/_{m}$ per second:

Assuming 60 ships to be raised within 24 hours we have

(24 × 60) : 60 = ... 24 min.
at our disposal; taking for the exchange of the ships . . . . . . 3 „
for the attendance at the gates . . . . 1 „
and a reserve . . . . 2 „
there remain . . . 18 Min.

time for the real work or motion. Since the whole length of the rope is: $\pi R = 44{\cdot}67$ m the speed of the rope amounts to: $v = 44{\cdot}67 : (18 \times 60) = 0{\cdot}041361$ m and the maximum power is: 2,708.300 : 14·22 = 190.500 kg

The maximum work upon the shaft of the drum is therefore:

$$\frac{190.500 \times 0{\cdot}041361}{75} = \ldots\ldots\ldots\ldots 105 \text{ HP.}$$

to this must be added 20 % on account of waste of power in the two transmitting gearings required for small speed . . . . 21 „
total . . . . 126 H Peff

By this result it is evident that a driving engine giving as usual 70 % workin capacity must be built for 180 H Pind.

The work required for one operation of raising a ship is found by ascertaining th average moment from the moment-curve diagrammatically shewn in Fig. 11., whereby th negative moments are supposed to be taken up by suitable brake — arrangement. Thi average moment amounts in our case to = 872·0 tm., therefore the average power com to = 872.000 : 14·22 = 62.000 kg and the average working capacity to:

$$\frac{62.000 \times 0{\cdot}041361}{75} = 34{\cdot}2 \text{ HP}$$

with 20 % to be added = 6·8 „
total = 41·0 H Peff

or according to the remark above, it results a working capacity of 58·6 H Pind.

b) Assuming an average speed of raising ships of 100 $^{m}/_{m}$ we have:

12.000 : 100 = 120 seconds = ... 2 minutes
to which figure must be added as said before . . . 6 „
One operation will therefore take the time of . . . 8 minutes

correspondig to $\dfrac{24 \times 60}{8}$ = 180 operations during 24 hours.

The speed of the rope: $v = 44{\cdot}67 : (2 \times 60) = 0{\cdot}372$ m.

The maximum work:

$$\frac{190.500 \times 0{\cdot}372}{75} = \qquad 945 \text{ HP}$$

the waste of power in a transmitting 10 % = 95 „
total 1040 H Peff or 1486 H P

The working capacity proper is therefore:

$$\frac{62.000 \times 0{\cdot}372}{75} = \qquad 308\ \mathrm{HP}$$

$$10\% = 32\ „$$

or 486 HPind. $\qquad$ total $\quad 340\ \mathrm{HP}_{eff}$

Supposing now that one kilogram of coals produces 1·5 HPind, we find that the consum of coals per hour amounts:

with $a)\quad 58{\cdot}6 : 1{\cdot}5 = 39{\cdot}1$ kg and

„ $\;b)\quad 486{\cdot}0 : 1{\cdot}5 = 324{\cdot}0$ „

and therefore the daily consume of coals — the real working time being with:

$a)\ (60 \times 18) : 60 = 18$ hours $\qquad 39{\cdot}1 \times 18 = 703{\cdot}8$ kg. $\quad$ and with

$b)$ its real working time being $\quad (180 \times 2) : 60 = 6$ hours

$324{\cdot}0 \times 6 = 1944{\cdot}0$ kg. $\quad$ fuel.

The apparatus therefore requires per meter height of raising ships, with:

$a)\quad 703{\cdot}8 : (60 \times 12) = 0{\cdot}98$ kg and with

$b)\quad 1944{\cdot}0 : (180 \times 12) = 0{\cdot}90$ kg of fuel

In case, howerer, hydraulic power is at hand, H (the slope) being 12·0 m a quanty or mass of water is required with:

$$a)\quad M = \frac{75 \times 58{\cdot}6 \times 18{\cdot}0}{12 \times 24} = 274{\cdot}7 \text{ second-liter}$$

r for each operation $\qquad 274{\cdot}7 : 60 = 4{\cdot}58$ sec. liter

$$\text{with } b)\quad M = \frac{75 \times 486 \times 6}{12 \times 24} = 769{\cdot}0 \text{ sec. liter}$$

r for each operation $\qquad 769 : 180 = 4{\cdot}22$ sec. liter.

From these figures the enormous advantage obtained by employing the improved ystem is best seen.

By comparing the required mass of water for working the improved apparatus with e quantity of water necessary for working an ordinary dike with chambers, the advantage tained by the improved apparatus is still more obvious. The mass of water required one operation for raising a ship amounts to:

$$4{\cdot}22 \text{ sec. liter} \times 60 \times 60 \times 24 = 364{\cdot}6\ \mathrm{m}^3$$

In the ordinary dike with chambers the filling of the ship's chamber, that is to say, two operations or motions: $\qquad K = 7426{\cdot}76\ \mathrm{m}^3$.

he working mass of water in the improved apparatus therefore amounts only to at required in an ordinary dike with chambers.

II. An apparatus

for raising ships of 67·0 meter of length, 8·2 meter of breadth, 1·8 meter of immersion is to be constructed for the height of lifting equal to 20·0 meter.

Therefore we have:

$B = 69{\cdot}0$ m, $k = 8{\cdot}8$ m, $H = 20{\cdot}0$ m, $H_2 = 2{\cdot}5$ m, $H_1 = 20{\cdot}0 - 2{\cdot}5 = 17{\cdot}5$ m.

The drawing fig. 7 shows:

$B_1 = 73{\cdot}4$ m, $B_2 = 74{\cdot}5$ m, $L = 74{\cdot}5$ m.

Supponing $n = 16$ and $c = 1{\cdot}5$ m il follows:

$$\lesssim b_2 = 2 \times 16 \times 0{\cdot}07 = 2{\cdot}24 \text{ m.}$$

$$\lesssim b_1 = 74{\cdot}5 - (15 \times 1{\cdot}5) = 52{\cdot}0 \text{ m.}$$

$$\lesssim b = 52{\cdot}0 - 2{\cdot}24 = 49{\cdot}76 \text{ m.}$$

$$b = 49{\cdot}76 : 16 = 3{\cdot}11 \text{ m.}$$

$$K = (8{\cdot}8 \times 20{\cdot}0 \times 73{\cdot}4) + (2{\cdot}5 \times 8{\cdot}8 \times 1{\cdot}1) = 12\,942{\cdot}6 \text{ m}^3.$$

The area of the ship's chamber is in the bottom part:

$$k\,B_1 = 8{\cdot}8 \times 73{\cdot}4 = 645{\cdot}92 \text{ m}^2$$

and in the top part:

$$k\,B_2 = 8{\cdot}8 \times 74{\cdot}5 = 655{\cdot}6 \text{ m}^2$$

After introducing the real amounts we have:

$$54{\cdot}24\ F = 13.088{\cdot}2 + 2{\cdot}24\ \pi\ R^2$$

from which we find:

$R = 21{\cdot}27$ m; $R^2 = 452{\cdot}41$; $\pi\ R^2 = 1421{\cdot}92$ m^2

because of $F = 300{\cdot}0$ m^2; but from the second equation we find $F = 300{\cdot}2$ m^2 when $\alpha = 61{\cdot}9^0$.

The area of displacing:

$$\pi\ R^2 - F = 1421{\cdot}92 - 300{\cdot}2 = 1121{\cdot}72 \text{ m}^2$$

and the whole area of displacement:

$$\frac{\pi}{2}\left(R^2 - \left(\frac{H}{2}\right)^2\right) = 553{\cdot}89 \text{ m}^2$$

and the capacity of the same $= 27.561{\cdot}32$ m^3

Supposing again 12 phases, there will be for each phase an area of displacement $e = 46{\cdot}15$ m^2 and a mass of displacement of $= 2296{\cdot}7$ m^3

The annexed table III contains all the figures obtained in the same n the first problem, but it must be noticed, that the own weight of the displa calculated at 250 t or that of the whole apparatus came to 4000 t which figures have been introduced into the calculation.

The first counterweight is found through the balance of the 3rd and the 9th phases:

$$(82.391{\cdot}9 + 49.924{\cdot}5)\ {}^1\!/_2 = Z_1 \,.\, z_1 \,.\, \sin 45^0 = 66.158{\cdot}2 \text{ tm.}$$

$$Z_1 \,.\, z_1 = 93.561{\cdot}4 \text{ tm.}$$

$$f\ z_1 = 93{\cdot}561{\cdot}4 : 49{\cdot}76 = 1880{\cdot}2$$

to this corresponds an angle $\gamma = 41{\cdot}5^0$ for:

$$f\ z_1 = (327{\cdot}8 \times 13{\cdot}04) - (224{\cdot}5 \times 10{\cdot}62) = 1890{\cdot}0$$

ar

d therefore:

$$f = 327{\cdot}8 - 224{\cdot}5 = 103{\cdot}3 \text{ m}^2$$

$$z_1 = 1890{\cdot}0 : 103{\cdot}3 = 18{\cdot}29 \text{ m}$$

$$Z_1 = 103{\cdot}3 \times 49{\cdot}76 = 5140{\cdot}2 \text{ t.}$$

The second counterweight is found through the balance of the 0 position and the rd phase:

$$M_2 = Z_2\ z_2 = f. \lessgtr b.\ z_2 = 16.233{\cdot}7 : 1{\cdot}70711 = 9509{\cdot}4 \text{ tm.}$$

$$f\ z_2 = 9509{\cdot}4 : 49{\cdot}76 = 191{\cdot}1$$

$$f\ z_2 = (4{\cdot}0 \times 2{\cdot}46) \times 19{\cdot}2 = 191{\cdot}1$$

$$Z_2 = f \lessgtr b = 489{\cdot}6 \text{ t.}$$

The third counterweight must amount to:

$$P = (\pi\ R^2 - F)\ b.\ 1000 \text{ kg} = 1121{\cdot}72 \times 3110 = 3{,}488.550 \text{ kg}$$

$$p = \frac{P}{2} = \qquad 1{,}744.275 \text{ „}$$

$$\frac{Q}{16} = 4.000.000 : 16 = 250.000$$

Axle and boss: $= 20.000 =$ 270.000 „

$$\begin{array}{rl} Z_1 = & 5140{\cdot}2 \text{ t} \\ Z_2 = & 489{\cdot}6 \text{ t} \\ \hline & 5629{\cdot}8 \text{ t} : 16 = \end{array} \qquad 351.860 \text{ „}$$

$$Z_3 = 1{,}122.415 \text{ kg}$$

The area of this 3rd counterweight will have the breadth, „H“ being supposed to be − of:

$$l = 1122{\cdot}415 : (20 \times 3{\cdot}11) = 18{\cdot}05 \text{ m.}$$

Calculation of the elements of the structure.

The axle of the displacer is only charged at both its extremities — its length being smaller than before — (see fig. 12), so that p : 2 works upon both, the required diameter $d = 857\ ^{m}/_{m}$ — the material being steel and the stress being 10 kg.

The gudgeons must be of a thickness $d = 334\ ^{m}/_{m}$.

The foundation must be armed by bottom girders of the lenght calculated as follows:

$$1{,}744.275 : 2000 = 872{\cdot}0\ m^3$$
$$20\% = \underline{174{\cdot}4\ „}$$
$$1046{\cdot}4 : (1{\cdot}5 \times 30) = 23{\cdot}3\ m$$

The bottom girders have a height:

$$H = 3240\ ^{m}/_{m}; \qquad \frac{H - h}{2} = 81\ ^{m}/_{m}$$

and ***the top girders,*** when $l = 10.000\ ^{m}/_{m}$ have a height:

$$H = 2230\ ^{m}/_{m}; \qquad \frac{H - h}{2} = 56\ ^{m}/_{m}$$

The wire ropes must overcome a power of:

$$9{,}509.400 : 21{\cdot}27 = 447.080\ kg$$

and each displacer must be provided with a rope the diameter of which is $d = 51{\cdot}1\ ^{m}/_{,}$

The strength or power of the driving engine:

a) Assuming 60 ships to be raised within 24 hours, 18 minutes (as said befor will be the time for each operation. One turn of the rope is $\pi R = 66{\cdot}82$ m an therefore the speed of the rope:

$$v = 66{\cdot}82 : (18 \times 60) = 0{\cdot}061962\ m.$$

and the maximum working capacity:

$$\frac{447.080 \times 0{\cdot}061962}{75} = 370\ HP$$
$$20\ \% = \underline{74\ „}$$
$$\text{total} \quad 444\ HP_{eff}$$

or 630 H Pind.

The average moment is obtained at 3096 tm, therefore the average power or strengt of the ropes will be 145.560 kg and the working capacity really required for one operation is

$$\frac{145.560 \times 0{\cdot}061962}{75} = 120\ HP$$
$$20\% \quad \underline{24\ „}$$
$$\text{total} = 144\ HP_{eff}$$

or 200 H Pind.

b) Assuming an average speed of raising ships of 100 $^{m}/_{m}$ the operation takes up:

20.000 : 100 = 200 sec. = 3·3 minutes
added as before = 6·0 „
total = 9·3 minutes

that means that in 24 hours about 155 operations will be possible. The speed of the ropes is in this case: v = 0·3341 m and therefore the maximum working capacity:

$$\frac{447{\cdot}080 \times 0{\cdot}3341}{75} = 2000 \text{ H P}$$

10% = 200 „
total = 2200 H P$_{\text{eff}}$
or 3100 H P$_{\text{ind}}$

The real working capacity is:

$$\frac{145.560 \times 0{\cdot}3341}{75} = 649 \text{ HP}$$

10% = 65 „
total = 714 H P$_{\text{eff}}$
or 1020 HPind.

The consume of coals per hour is with:

a) 200·0 : 1·5 = 133·3 kg and with
b) 1020·0 : 1·5 = 680·0 kg

The real time of one operation:

a) (60 × 18) : 60 = 18 hours
b) (155 × 3·3) : 60 = 8·6 „

The daily consume of fuel is therefore:

a) 133·3 × 18 = 2400 kg
b) 680·0 × 8·6 = 5848 kg

The consume of fuel per meter of lifting the ship is with:

a) 2400 : (60 × 20) = 2·0 kg
b) 5848 : (155 × 20) = 1·9 kg of coals

If water power is employed you require:

a) 562·25 sec. lit. or 9·37 sec. lit. per operation
b) 1370·60 „ „ 8·80 „ „ „

The calculation finally results in the fact, that the improved apparatus requires only 11·8 % of the working water mass, which is necessary for raising the ship by an ordinary dike with chambers.

III. An apparatus

for raising sea-ships of 235 meter of length, 25 meter of breadth, 10·0 meter immersion, to be constructed for a lifting height of 8 meter.

Therefore we have:

$B = 241{\cdot}0$ m; $k = 27{\cdot}0$ m; $H = 8{\cdot}0$ m; H_1 being dispensed with, $H_2 = H = 8{\cdot}0$ m

Supposing again $c = 1{\cdot}5$ m and $n = 44$

the measurements of fig. 8. being: $B_2 = 256$ m. $L = 255{\cdot}46$ m.

we obtain:

$$\lesseqgtr b_2 = 2 \times 44 \times 0{\cdot}07 = 6{\cdot}16 \text{ m.}$$
$$\lesseqgtr b_1 = 255{\cdot}46 - (43 \times 1{\cdot}5) = 190{\cdot}96 \text{ m.}$$
$$\lesseqgtr b = 190{\cdot}96 - 6{\cdot}16 = 184{\cdot}8 \text{ m.}$$
$$b = 184{\cdot}8 : 44 = 4{\cdot}20 \text{ m.}$$

$$K = B_2\ k.\ H = 256{\cdot}0 \times 27{\cdot}0 \times 8{\cdot}0 = 55.296 \text{ m}^3$$

The unvarying area of the ship's chamber is: $k.\ B_2 = 6912{\cdot}0 \text{ m}^2$

It we introduce now in this equation the value of the reference letters we have

$$197{\cdot}12\ F = 55.509{\cdot}875 + 6{\cdot}16\ \pi\ R^2$$

and therefore:

$R = 16{\cdot}78$ m, $R^2 = 281{\cdot}57$, $\pi R^2 = 884{\cdot}55 \text{ m}^2$, $F = 309{\cdot}6 \text{ m}^2$, when $\alpha = 76{\cdot}15^0$

The area of the displacer: $\pi R^2 - F = 884{\cdot}55 - 309{\cdot}6 = 574{\cdot}95 \text{ m}^2$

The whole area of displacement:

$$\frac{\pi}{2}\left(R^2 - \left(\frac{H}{2}\right)^2\right) = \frac{\pi}{2}\,(281{\cdot}57 - 16{\cdot}0) = 417{\cdot}14 \text{ m}^2$$

and the corresponding capacity $= 76.920{\cdot}7 \text{ m}^3$

Supposing again 12 phases, the area of displacement

of one phase is . . . . $e = 34{\cdot}76 \text{ m}^2$

and the corresponding capacity $= 6.410{\cdot}0 \text{ m}^3$

Taking these figures as a base, table V has been drawn up in the well known manner, the own weight of a displacer being introduced as 220 t, therefore their total weight $Q = 9680$ t.

The first counterweight is found by:

$$f\,z_1 = \frac{M_1}{\lesssim b} = \frac{(173.195{\cdot}5 + 134{\cdot}700)\ {}^1\!/_2}{0{\cdot}70711 \times 184{\cdot}8} = 1178{\cdot}1$$

$\gamma = 46^0$

$$f\,z_1 = (226{\cdot}05 \times 10{\cdot}022) - (140{\cdot}01 \times 7{\cdot}77) = 1177{\cdot}7$$

$$f = 226{\cdot}05 - 140{\cdot}01 = 86{\cdot}04 \text{ m}^2$$

$$z_1 = 1177{\cdot}7 : 86{\cdot}04 = 13{\cdot}69 \text{ m}$$

$$Z_1 = f. \lesssim b = 86{\cdot}04 \times 184{\cdot}8 = 15.900{\cdot}2 \text{ t.}$$

The second counterweight is ascertained from the moment of the 3rd phase:

$$19.247{\cdot}7 : 1{\cdot}70711 = 11.275{\cdot}2$$

which is the required counterweight for the 0 position, out of which all the moments of the other phases are calculated. All these moments and also those resulting from them are contained in table VI. The second counterweight has the following dimensions:

$$f\,z_2 = 11.275{\cdot}2 : 184{\cdot}8 = 61{\cdot}01$$

$$f = 1{\cdot}64 \times 2{\cdot}33 = 3{\cdot}82 \qquad z_2 = 15{\cdot}96 \text{ m}$$

$$Z_2 = f. \lesssim b = 705{\cdot}94 \text{ t.}$$

The third counterweight is ascertained:

$$Z_3 = \frac{P}{2} - (Q + Z_1 + Z_2)$$

$$P = (\pi R^2 - F)\ b.\ 1000 \text{ kg} = 574{\cdot}95 \times 4200{\cdot}0 = 2{,}414.790 \text{ kg}$$

$$p = \frac{P}{2} = \qquad 1{,}207.395 \text{ ,,}$$

$$\frac{Q}{44} = 9{,}680.000 : 44 = 220.000$$

$$\text{Axle and boss} = \underline{30.000} \qquad 250.000 \text{ ,,}$$

$$\begin{array}{l} Z_1 = 15.900{\cdot}2 \text{ t} \\ \underline{Z_2 = 705{\cdot}94 \text{ t}} \\ 16.606{\cdot}14 : 44 = \qquad \underline{381.957 \text{ ,,}} \\ \text{Remains } Z_3 = \qquad 555.438 \text{ kg} \end{array}$$

The height of this counterweight being 8·0 m., its breadth is —

$$l = \frac{555{\cdot}438}{8{\cdot}0 \times 4{\cdot}2} = 16{\cdot}53 \text{ m.}$$

Calculation of the elements of the structure:

The axle is charged as in the first problem, at three points (see fig. 13.) and its diameter must be: $d = 960\ ^m/_m$.

The gudgeons must have their diameter: $d = 277\ ^m/_m$,

The foundation must be armed along 22 meter, therefore

the top girder has $H = 1{\cdot}840\ ^m/_m \qquad \frac{H - h}{2} = 36\ ^m/_m$ and

the bottom girder $H = 2{\cdot}740\ ^m/_m \qquad \frac{H - h}{2} = 69\ ^m/_m$

The tightening screws require a section:

$$f = \frac{p}{10} = 120.740\ ^m/_m{}^2 \text{ ; that is to say:}$$

2 rows at 6 screws $d = 100\ ^m/_m$, $f = 7854 \times 12 = 94.248\ ^m/_m{}^2$

2 „ „ 4 „ $d = 60{\cdot}5$ „ $f = 3318 \times 8 = 26.546$ „

total $= 120.794\ ^m/_m{}^2$

The wire ropes must overcome the maximum strain of:

$$11{,}275.200 \text{ kg. m} : 16{\cdot}78 \text{ m} = 672{\cdot}000 \text{ kg}$$

that is to say 15.200 kg per displacer; the rope must have $d = 33{\cdot}2\ ^m/_m$.

The driving engine:

a) assuming a working capacity of 60 operations as before, 18 minutes time f each is given so that the speed of rope is:

$$v = \pi R : (18 \times 60) = 52{\cdot}714 : 1080 = 0{\cdot}0488 \text{ m}$$

and the maximum working capacity is:

$$\frac{672.000 \times 0{\cdot}0488}{75} = 438 \text{ HP}$$

$$20\,\% = 87 \text{ „}$$

$$\text{total} = 525 \text{ HP}_{\text{eff}} \text{ or } 750 \text{ HPind}$$

b) assuming the speed of lifting $= 100\ ^m/_m$ the whole operation will last

$8000 : 100 = 80$ Sec. $= 1{\cdot}3$ minutes

add. as before $= 6{\cdot}0$ „

total $= 7{\cdot}3$ Min.

that is to say, in the course of 24 hours about 193 operations of lifting ships will be possible. The speed of the rope is $v = 0{\cdot}659$ m and the maximum working capacity must be:

$$\frac{672.000 \times 0{\cdot}659}{75} = 5900 \text{ HP}$$

$$10\,\% = 590 \text{ „}$$

$$\text{total} = 6490 \text{ HP}_{\text{eff}} \text{ or } 9.270 \text{ HP}_{\text{ind.}}$$

It is obvious that to such an immense problem to raise so many sea-ships in such short time also the means must be of corresponding size. Since, howerer, such collosal working capacity will never be required, the calculation has nevertheless shewn its possibility. But I shall refrain from following up this kind of alternative.

The average moment amounts to 3803 tm, the average strength in the rope must erefore be 226.630 kg, and the average working capacity is:

$$\frac{226.630 \times 0{\cdot}0488}{75} = 146 \text{ HP}$$

$$20\,\% = 29 \text{ „}$$

$$\text{total} = 175 \text{ HP}_{\text{eff}} \text{ or } 250 \text{ HP}_{\text{ind.}}$$

The consume of fuel per hour is 250 : 1·5 = 166·7 kg. By working 18 hours per day
s consume will be daily: 166·7 × 18 = 3.000 kg and the consume of fuel
r meter lifting of a ship: 3000 : (60 × 8) = 6·25 kg coals.

If hydraulic power be employed, this improved apparatus requires for 60 operations ring the day 1757·8 sec. lit or 29·3 sec. lit water pro operation. This quantity of water equal to only 9·1% of the mass required in an ordinary dike with chambers.

Since the improved apparatus in the foregoing case must have a displacing chamber ong the whole length of the ship, the corresponding shaft „E“ transmitting power (see . 3.) must be of the same length and since it is driven at its centre, it must be of greater meter. It is therefore necessary to apply more than one motor for actuating it and this easily effected by employing a dynamo, which causes also all the secondary motors to rk uniformly. Another modification for attaining this object would consist in dividing the isplacers into two groups one aside the other, but both working on to the common chamer of the ship. This division is moreover advisable in apparatus for the big ships and in nse the lifting height is considerable because then the diameter of the displacer could be maller. In order to prove what I just said, I will solve the following problem:

IV. An apparatus

for raising similar big sea-ships as before to a lifting height of 15 meter is to be constructed.

We have therefore: $B = 235{\cdot}0$ m. $k = 27{\cdot}0$ m. $H_2 = 11{\cdot}0$ m.

$H = 15{\cdot}0$ m. $H_1 = 15 - 11 = 4{\cdot}0$ m.

fig. 9 of the drawing we find:

$B_1 = 252{\cdot}6$ m. $B_2 = 256{\cdot}0$ m

4

The displacing cylinders are divided in two groups, so that half of the breadth of the ship's chamber is served by each group; we may therefore in the following calculation only consider one system of displacing cylinders for $k^1/_2$ = 13·5 m. — half of the whole breadth of the ship's chamber. Supposing as before c = 1·5 m, but the displacing chamber a little shorter (only for the sake of calculating a modification) that is to say: L = 230·5 m and introducing n = 50, it follows:

$$\lesssim b_2 = 2 \times 50 \times 0{\cdot}07 = 7{\cdot}0 \text{ m.}$$

$$\lesssim b_1 = 230{\cdot}5 - (49 \times 1{\cdot}5) = 157{\cdot}0 \text{ m.}$$

$$\lesssim b = 157{\cdot}0 - 7{\cdot}0 = 150{\cdot}0 \text{ m.}$$

$$b = 150 : 50 = 3{\cdot}0 \text{ m.}$$

$$K\, ^1/_2 = (13{\cdot}5 \times 4{\cdot}0 \times 252{\cdot}5) + (11{\cdot}0 \times 13{\cdot}5 \times 256{\cdot}0) = 51.651{\cdot}0 \text{ m}^3.$$

The area of the chamber of the ship is:

in its bottom part: $k_{1/_2}\ B_1 = 3410{\cdot}0 \text{ m}^2$ and

in its top part: $k_{1/_2}\ B_2 = 3456{\cdot}0$ „

By introducing the real value into the equation we obtain:

$164{\cdot}0\ F = 51.980{\cdot}7 + 7{\cdot}0\ \pi R^2$ and to thi correspond:

$R = 20{\cdot}8$ m, $R^2 = 432{\cdot}64$, $\pi R^2 = 1359{\cdot}18 \text{ m}^2$

$F = 375{\cdot}0 \text{ m}^2$ and the angle $\alpha = 68{\cdot}9^0$

The area of the displacer:

$\pi R^2 - F = 1359{\cdot}18 - 375{\cdot}0 = 984{\cdot}18 \text{ m}^2$

The area of displacement = 591·23 „

the capacity of the displacement = 88.684·5 m³.

Supposing again 12 phases, each of them will have

an area of displacement $e = 49{\cdot}27 \text{ m}^2$

a mass of displacement $= 7390{\cdot}4 \text{ m}^3$.

All the results as regards these calculations are contained in table VII, the (weight of a displacer being 210·0 t and that of a whole system Q = 10.500 t.

The first counterweight is obtained by balancing the 3rd phase with the 9th ph

$$(259.074{\cdot}9 + 174.947{\cdot}9)\ ^1/_2 = Z_1\ z_1 \sin 45^0 = 217.011{\cdot}4 \text{ tm.}$$

$$Z_1\ z_1 = 306.899{\cdot}0 \text{ tm.}$$

$$f\ z_1 = Z_1\ z_1 : \lesssim b = 306.899 : 150 = 2046{\cdot}0 \qquad \gamma =$$

$$(336{\cdot}0 \times 12{\cdot}5) - (216{\cdot}29 \times 9{\cdot}87) = 2065{\cdot}3$$

$$f = 336{\cdot}0 - 216{\cdot}29 = 119{\cdot}71 \text{ m}^2$$

$$z_1 = 2065{\cdot}3 : 119{\cdot}71 = 18{\cdot}09 \text{ m}$$

$$Z_1 = f.\ \lesssim b = 119{\cdot}71 \times 150{\cdot}0 = 17.956{\cdot}5 \text{ t.}$$

The second counterweight is obtained by the balance of the 0 position and the phase:

$$M_2 = f. \lesssim b.\ z_2 = 42.063{\cdot}5 : 1{\cdot}70711 = 24.640{\cdot}2 \text{ tm.}$$

$$f\ z_2 = 24.640{\cdot}2 : 150{\cdot}0 = 164{\cdot}3$$

$$= (4{\cdot}0 \times 2{\cdot}2) \times 18{\cdot}8 = 165{\cdot}4$$

$$Z_2 = f. \lesssim b = 1320{\cdot}0 \text{ t.}$$

The third counterweight results as follows:

$$P = (\pi R^2 - F)\ b.\ 1000 \text{ kg} = 984{\cdot}18 \times 3000 = 2{,}952.540 \text{ kg}$$

$$p = \frac{P}{2} = \qquad 1{,}476.270 \text{ „}$$

$$\begin{array}{lrr}
\frac{Q}{50} = 10{,}500.000 : 50 = & 210.000 & \\
\text{axle and boss} = & \underline{18.000} & 228.000 \text{ „} \\
Z_1 = 17.956{\cdot}5 \text{ t} & & \\
\underline{Z_2 = \ \ 1.320{\cdot}0 \text{ t}} & & \\
19.276{\cdot}5 \text{ t} : 50 = & & \underline{385.530 \text{ „}} \\
Z_3 = & & 862.740 \text{ kg.}
\end{array}$$

Its height being = H = 15·0 m, we obtain its breadth:

$$l = 862{\cdot}74 : (15 \times 3) = 19{\cdot}24 \text{ m.}$$

Calculation of the elements of the structure:

The axle is provided with two bronze-fittings (see fig. 14) and is therefore ged with a load of $p/_2$ at each end,

the required diameter being d = 805 m/m

The gudgeons have a diameter d = 307 „

The foundation must be armed along its border:

$$1{,}476{\cdot}270 : 2 = 738{\cdot}14 \text{ m}^3$$

$$20\,\% = \underline{147{\cdot}63} = 885{\cdot}77 : (1{\cdot}5 \times 29{\cdot}0) = 24{\cdot}0 \text{ m.}$$

therore the dimensions of the:

bottom girder: $H = 3170$ m/m $\quad \dfrac{H - h}{2} = 74$ m/m

top girder: $H = 2040$ „ $\quad \dfrac{H - h}{2} = 50$ „

The wire ropes must overcome a strain of:

$$24{,}640.200 : 20{\cdot}8 = 1{,}185.000 \text{ kg}$$

r each rope 23700 kg, for which purpose the diameter must be d = 47·1 m/m.

he strength of the driving engine. We intend to determine this strength for s in the course of 24 hours, which working capacity must be considered as we take into account that each operation is performed for one of the biggest sea-ships or in its stead 9 ordinary river-ships may be raised together to a level of 1 meter height. Each operation is made in 18 minutes (as before) and the speed of the rope i

$$v = \pi R : (18 \times 60) = 0{\cdot}0605 \text{ m.}$$

whilst the maximum working capacity is: $\dfrac{1,185.000 \times 0{\cdot}0605}{75} = 954$

$$20\% = \underline{191} = 1145 \text{ HP}_{\text{eff.}}$$

Since, however, both halves are driven by the common engine, the latter must b constructed for 2290 HP_{eff} or for 3272 HP_{ind}.

The average working capacity must be calculated from the average moment of ro tation = 7.377·5 tm. or from the power of the rope corresponding to this moment = 354.700 kg:

$$\frac{354.700 \times 0{\cdot}0605}{75} \times 2 = 572$$

$$20\% = \underline{114} = 686 \text{ HP}_{\text{eff}} \text{ oder } 950 \text{ HP}_{\text{ind}}$$

The consume of fuel per hour is: 950 : 1·5 = 633·3 k
and per day the effective working time being 18 hours-this consume is: 633·3 × 18 = 11.400 k
and per meter lifting height. 11.400 : (60 × 15) = 11·56 k

In case of hydraulic power being employed, the improved apparatus requires pe day 3567·5 sec. lit. or for each operation 59·46 sec. lit., a quantity of water which is belo $10^0/_0$ of the mass required by an ordinary dike with chambers.

From all the foregoing problems it may easily be observed that the moments rotation are more readily equalized by the counterweights, when the difference of level comparatively small and that also the required strength of the driving means, then t consume of fuel and that of water are much smaller per one meter lifting height.

V. An apparatus

for raising ships as mentioned in problem II, but at a lifting height of 36 meter, is to be constructe

If this problem would be solved in the same manner as the others, the diamet of the displacer or displacing chamber would result as too great for conveniently co structing. But we are capable of solving this problem by arranging tree lock-basins, eac for varying the level up to 12 meter, or in combining two lock-basins each for 18 met lifting height, all working into the same chamber for placing the ship and all being actuat by a common crane-arrangement and a common driving engine. In fig. 10 three sets cylinders serving the same basin, for varying the water level at 12 meter each are shew as I. II. III., of which the two lower ones communicate by the channels „a“ with the bas for the ship, whilst the top apparatus III is in direct communication with this basin, sim larly arranging the passages „b_3“ as it is usual with simple apparatus for raising ship The channels „a“ are each provided with a lock-arrangement „d“ and all communicate wi the channel „c“, which takes up the outlets „b_1“ and „b_2“.

Each operation of raising a ship consists in this case of three, first the lo ratus I is used to raise the ship to the level I; the channels „a_1“ are then loc second apparatus is started. After raising the ship to the level II, the chann be locked and the third apparatus III is used for raising the ship to the highest level III. It is not necessary to provide the passages or channels „b_3" with locking devices. If the ship is to be sunk, it is first lowered to the level II by employing the apparatus III, the channels „a_2" are then opened and apparatus II begins working. As soon as the ship is lowered to level II the channels „a_1" must be cleared so that the ship may be sunk to the first level I by means of the lock-basin I. Locking of the channels „a_1" and „a_2" is absolutely necessary because otherwise the accumulated water would be enabled to escape trough the passages and the lower apparatus. The locking arrangements may be of any suitable kind; in fig. 10 an arrangement is shewn similar to that of „Desfontaines" or the angular gate of „Nagel and Kaemp"; the latter comprises two doors „e" and „f" being placed so as to include a right angle and forming a closing gate along the whole width of the channel—the lower wing or door „f" being of somewhat greater dimensions than the other one „e".

Said angular gate is capable of turning round its pivot „g" and of opening itself when turned through an angle of 90° starting from its closing position which is shewn in the drawing towards the bottom whereby the lower wing „f" enters the chamber „d_2" forming there tight joint with its walls. This chamber „d_2" communicates with a channel „h" which itself is in communication on one side by a vertical channel „k" and by a horizontal one „i" with the top-container; the channel „i" is situated at the same level with this container and capable of being locked by gates „m". Channel „h" terminates in the lower container, where it is capable of being locked. In fig. 10., this locking is effected by a cylinder-valve „l".

The mode of operation is very simple. If channel or chamber „d_2" is to be closed, as indicated in the drawing, valve „l" must be shut and the pressing water mass of the top container is let off into the chamber „d_2". As soon as the water supply from above is stopped by the gate „m" and valve „l" is opened, this press water is allowed to flow off, whilst the water mass from the ship's basin runs through the cannel „d_2" into the chamber of the displacer, thus automatically opening by its pressure said angular gate. The valves „l" are actuated from the top of the apparatus so that attending to them is much facilitated, the rod of the valve being provided with an extension.

Such apparatus having three lock-basins arranged in steps is driven by a common ngine and has a common crane-arrangement, the upper ropes running over guide pulleys both the top lock-basins.

Corresponding with each displacing cylinder, a crane-drum to which a coggear is rmly fixed. The crane-drums of all three systems loosely rotate side by side upon a common haft, the U-shaped rims I and III being found at the sides and rim II at the middle part f the apparatus. The small toothed wheels corresponding to them are firmly mounted upon ree shafts „E" (common to each system) which are alternately connected by couplings the motor.

A great advantage of such an arrangement is constituted by thus centralizing the ferent lock-basins and by the resulting economy in wages, further by a more constant d longer lasting mode of working the engine, finally by the possibility to employ fewer ntainers of greater length, wherefore fewer ships are required for working the plant. But s more dificult to accomodate such a complicated plant to the land, enormous removal earth becoming necessary and long artificially constructed containers being required. reover also the working capacity of such a plant will be somewhat reduced on account he longer duration of the operation and the great difference between the levels of the ins. As regards the duration of one operation - supposing the lifting speed to be 100 m/m second - we have:

gr 36.000 : 100 = 360 Sek. . . . . = 6 Minuten
added for stoppings . . . . 6 „
r attending the lock-arrangement . . . . 1 „
a total of . . . . 13 Minuten.

That means, that such a more complicated plant is only capable of performing $\frac{24 \times 60}{13} = 110$ operations in the course of 24 hours, instead of 180 as it was shewn with a simple plant for a lifting height of 12 meter.

The other conditions in respect of power consume remain, howerer, the same as those in a simple plant.

VI. An apparatus

for raising the same kind of ships to a height of 12 meter, but with a working capacity enabling 180 operations in the course of 24 hours.

If such conditions are given and a suitable plant seems to be required, a combination of two basins will be adopted, if the lifting speed of 100 $^m/_m$ must not be exceeded and the quiet motion of the ship is not to be disturbed. Such a plant (see fig: 15.) simply consists of two simple apparatus, driven by a common motor and symmetrically disposed one beside the other. In this double plant, the arrangement must be so that at each operation one apparatus performs the raising simultaneously with the other apparatus wherein the lowering of the level takes place.

This kind of operations is preferable to the mode by which a simultaneous raising or lowering takes place in both the apparatus and it is the more advantageous as a further reduction of the working moments is obtained, as may be seen in the adjacent table. The arrangemen remains still the same as that of the simpl apparatus with the difference that the drums c the crane must be made twice as broad for th reception of the ropes.

Phase	I.	II.	Resulting Moments
—	— 2680·0	+ 2680·0	—
1	+ 339·3	— 87·7	+ 251·6
2	+ 2023·9	— 2257·0	— 223·1
3	+ 2680·0	— 2679·0	—
4	+ 1906·1	— 2708·3	— 802·2
5	+ 745·8	— 1427·6	— 681·8
6	— 363·8	— 363·8	— 727·6
7	— 1427·6	+ 745·8	— 681·8
8	— 2708·3	+ 1906.1	— 802·2
9	— 2679·0	+ 2680·0	—
10	— 2257·0	+ 2023·9	— 223·1
11	— 87·7	+ 339·3	+ 251·6
12	+ 2680·0	— 2680·0	—

It is obvious that the costs of erecting such a more complicated plant will almo double those of a single apparatus and that this plant will only be chosen when the great working capacity is required or in case it is the question of creating an apparatus as a r serve for emergencies, since the one may be independently used even in case the oth incurs a working disturbance, when only the ropes of the latter must be loosened.

Before closing this treatise, it may be allowed to add the following

Critical Observations.

It has already been mentioned before that the improved system „Pokorný“ does require any extra watermass and that one and the same quantity of water, being cau to move to and fro serves as a means for floating and raising the ships. But it is that the top container may nevertheless lose some of its contents by evaporatio and trough the gates, and that some small extra supply of water will be requi tries now, where such extra supply of water is not at hand, the apparatus employed as a pump for hoisting water from the bottom container to the top container, when the apparatus must be constructed accordingly. This is effected by tacking a somewhat greater lifting height - say about 0·2—0·3 m. more-into the calculation, by which means a certain watermass extending over the whole area of the exit will always remain in the top container after each operation. The water escaping from the gate of the chamber will in this manner allways be renewed, when the bottom gate of the lower container automatically opens. The results of the calculation in such case are of more or less increased as otherwise required.

The costs of constructing the improved apparatus system „Pokorný“ are considerable smaller than those of any other vertical plant for raising ships. When compared with the apparatus hitherto used wherein inclined planes serve for lifting the ship, the costs of the apparatus „Pokorný« only become equal to that of the other, when a lifting height of circa 40 meter is required. The apparatus with inclined planes are very expensive on account of the termini, the length of the way does not matter so much.

For this reason the latter happens to be comparatively less expensive when it is the question of greater difference of level and much more expensive as the apparatus system „Pokorný“ when smaller differences are required. The costs of those with inclined planes will be smaller for lifting heights of more than 40 meter than the improved system, but are much higher when only lifting heights below 40 meter are required. But it must not be overlooked that the old fashioned apparatus can only be employed for ships of smaller dimensions.

All the advantages adhering to the ordinary dike with chambers are still more to be found in the improved system employing revolving displacers; the principal advantage being, however, the absolute quietness of the operation and the complete - safety of the ships when raised, the required watermass being always conveyed below the water level and by means of very large channels, situated and distributed along the whole length of the chamber. On the other hand, it is well known that the arrangement for raising ships hitherto in use—being provided with troughlike chambers, especially, however those with stopes—are subjected to considerable disturbance as soon as the slightest variance of the speed takes place, and when the troughs must be adjusted or put in order. All these drawbacks diminish the speed of the ships and necessitate arrangements for controlling and rendering safe the apparatus, which only complicate it without dispensing wholy with the attendance formerly required. In operating, however, the improved apparatus system „Pokorný“, the engine driver must only be careful not to overwork the apparatus and also fo- preventing this, automatically working arrangements may be foreseen, like those alreadyr long ago introduced in the hoisting apparatus of mines.

The improved system making use of revolving displacers may be easily adopted for 20 meter lifting height—as proved by the solution of problem II — in its simple construction. The smaller the lifting height, the smaller proportionally will be the required working capacity, therefore also the costs of erecting the plant and difficulty for adapting the same to the soil will greatly be diminished, with every meter of smaller lifting height. Only the fact that the working cannot be executed in a centralised way seems to be a disadvantage. In making use of electrical power, however, a long series of steps for raising purpose could be arranged in a common central station. Such plant would allow an eminent equalisation of the powerconsume, but the mentioned disadvantage is only found in the greater expenses for attending to the steps. But compared with the expenses incurred for e return and interests of the working capital, the excess for the steps is very small indeed, he building of fine lock-basins, which are so intensely desired for considerable lifting does not reach such enormous prices as people think. The calculation of the costs ase will certainly be the best guide for judging the circumstances.

The system „Pokorný“ requires for the attendance per step three men: the engine driver, one man for the lock-gates and a stocker, the latter is replaced, when electric power is used, by the man required for the central station. The wages therefore do not increase the costs in the least.

The same may be said about the consume of the material as for instance for lubricating purposes, since only a small driving engine and slowly working cranes and displacers are employed in the improved apparatus.

The whole structure is as simple as ever possible. The plant consists of big parts, which all are set in motion very slowly and which are not liable to wear and tear. Compared with the improved apparatus all the hoisting means hitherto in use appear to be handled with great difficulties, thus for instance how complicated is the trough-like conveyor upon the inclined plane and how much are the numberless quick running and heavily loaded axles and wheels or the sliding path subjected to wear and tear and how difficult is their keeping in order.

All parts of the system are fully accessible. The engine and the crane stand con pletely by themselves, and the displacing bodies may be at any time inspected from outsid and inside.

Another advantage of the system is that no trough-like vessel or conveyor is to b attached to the container and no tightening of such vessel is required, which mean that no vaste of time or water takes place. The different levels of the water in the basi of the ship and that in the container are simply equalised or in case this has not bee effected completely, they are equalised automatically when the gate is opened. The wate surface is then uniform and exchange of ships may easily be performed.

But the chief advantage of the displacer system consists in its enormous workin capacity, the extraordinary small consume of labour and the possibility of raising ever th biggest sea-ships.

The working-effect: 180 operations for raising the ships up to 12 meter; or 15 operations for 20 meter or 110 operations up to 36 meter per day with a simple apparatu must be considered as very high; each meter of raising requires the consume of 0·9 o 1·9 kg of fuel respectively or a working water mass which represents only 9·7 or 11·8 % respectively of the quantity consumed in the ordinary dike with chambers. As shewn i the problems III. and IV., it is almost a play or game to raise the biggest sea-ships wit complete safety and quietness without any extra consume of working water and wit very small quantity of fuel or water to any desired lifting height — in short the improve apparatus is matchless and a surprising novelty.

Finally it is worth mentioning that the change of temperature, great heat or col weather has no influence upon the apparatus, there being no parts subjected to dilatation the wind finds no surfaces to work upon; in case of a very strong winter which prevent the trafic with ships, it is only necessary to revolve the displacers out of the water and empty the counterweights; when working is started again they must be filled up agai

We cannot refrain from mentioning the fact that when in case of the mechanis being damaged work needs not be interrupted as it may be continued with the water stor up in the top reservoirs just as it is done in an ordinary dike with chambers, so long water is not missing.

			Areas of the exits	The increasing levels			The immersed areas		$\frac{P}{t}$	$\frac{x}{m}$	m	$\frac{Px}{tm}$	The own weight		Px —	α
				unique	total			total	of the expelled water				q sin α	Qq. sin α	Qq. sin α	
0	—	—	—	—	—	Unvarying for each phase = 21·75667 m²	—	—	—	—	—	—	—	—	—	—
1	11·1	15·3	1249·8	0·923	0·923		13·41	35·17	1.865·4	6·858	6·444	12.793·1	0·742	1.707·5	11.085·6	15°
2	9·7	17·4	1176·9	0·981	1·904		16·45	73·37	3.891·5	6·028	6·727	23.458·2	1·451	3.373·3	20.084·9	30°
3	9·1	18·6	1146·3	1·008	2·912		18·23	113·36	6.012·6	5·221	6·846	31.391·8	2·052	4.514·5	26.877·3	45
4	8·7	19·4	1125·6	1·025	3·937		19·44	154·56	8.197·9	4·433	6·785	36.341·1	2·513	5.780·4	30.560·7	60
5	8·5	20·0	1115·7	1·034	4·971		20·66	196·97	10.447·3	3·671	6·671	38.352·0	2·803	6.447·2	31.904·8	75
6	8·4	22·0	1110·5	1·039	6·010		22·85	241·58	12.813·4	2·954	6·263	37.850·8	2·902	6.674·6	31.176·2	90
7	8·4	22·0	1110·5	1·039	7·049		22·85	286·19	15.179·5	2·292	5·908	34.791·4	2·803	6.447·2	28.344·2	105
8	8·5	20·0	1115·7	1·034	8·083		20·66	328·61	17.429·5	1·678	5·303	29.246·7	2·513	5.780·4	23.466·3	120
9	8·7	19·4	1125·6	1·025	9·108		19·44	369·80	19.614·2	1·134	4·758	22.242·5	2·052	4.514·5	17.728·0	135
10a	9·0	19·0	1141·3	0·392			7·26	409·69	21.629·9	0·672	4·159	14.535·3	1·451	3.373·3	11.162·0	150
10b	9·2	18·4	1160·9	0·609	10·109		10·87									
11	9·8	17·4	1192·4	0·968	11·077		16·23	447·68	23.745·0	0·299	3·527	7.099·7	0·742	1.707·5	5.392·2	165
12	10·9	15·3	1249·1	0·923	12·000		13·41	482·84	25.609·8	—	2·902	—	—	—	—	180
							221·76									

Table III.

0	—	—	—	—	—	Unvarying for each phase = 46·15 m²	—	—	- -	—	—	—	—	—	—	—
1	15·5	23·1	1.503·1	1·528	1·528		35·35	81·50	4.055·4	9·490	10·282	38.485·7	1·017	4.068	34.417·7	15
2	13·6	26·4	1.416·8	1·621	3·149		42·84	170·50	8.484·1	8·262	10·602	70.095·6	1·965	7.860	62.235·6	30
3	12·6	28·5	1.367·9	1·679	4·828		47·89	264·55	13.164·0	7·103	10·596	93.503·9	2·778	11.112	82.391·9	45
4	12·0	29·9	1.339·2	1·715	6·543		51·31	362·02	18.014·1	5·968	10·374	107.508·1	3·403	13.612	93.896·1	60
5	11·6	30·8	1.320·0	1·740	8·283		53·62	461·79	22.978·7	4·890	9·946	111.465·8	3·795	15.180	96.285·8	75
6	11·5	31·2	1.316·1	1·745	10·028		54·48	562·43	27.986·5	3·884	9·360	108.699·6	3·929	15.716	92.983·6	90
7	11·5	31·2	1.316·3	1·744	11·772		54·44	663·03	32.992·4	2·965	8·624	97.822·5	3·795	15.180	82.642·5	105
8	11·6	30·8	1.321·1	1·738	13·510		53·56	762·75	37.954·4	2·155	7·762	81.791·7	3·403	13.612	68.179·7	120
9	12·1	29·9	1.340·0	1·714	15·224		51·28	860·18	42 802·6	1·426	6·819	61.036·5	2·778	11.112	49.924·5	135
10	12·8	28·1	1.373·6	1·672	16·896		47·02	953·36	47.439·2	0·827	5·830	39.232·2	1·965	7.860	31.372·2	150
	13·4	26·9	1.403·0	0·498	17·394		13·18									
11	14·4	25·6	1.451·4	1·101	18·495		28·49	1041·19	51.809·6	0·356	4·831	18.444·2	1·017	4.068	14.376·2	165
12	15·9	22·8	1.526·0	1·505	20·000		34·37	1121·72	55.816·8	—	3·929	—	—	—	—	180
							567·83									

Phase	Lengths		Areas of the exits	The increasing levels		The immersed areas			P	x	y	Px	The own weigh			
	c.	d.		unique	total	e	f	total	t	m	m	tm	q sin α	Qq. si		
									of the expelled water							
0	—	—	—	—	- -	Unvarying for each phase = 34·76 m²	—	—	—	—	—	—	—	—	—	—
1	15·0	17·9	9.882·2	0·649	0·649		11·59	46·35	8.565·5	9·520	4·980	81.543·6	1·294	12.525·9	69.017·7	15
2	14·0	19·1	9.698·9	0·661	1·310		12·59	93·70	17.315·8	8·761	5·596	152.103·7	2·500	24.200·0	127.903·7	30
3	13·4	19·9	9.589·4	0·668	1·978		13·26	141·72	26.189·9	7·920	6·323	207.424·0	3·536	34.228·5	173.195·5	45
4	13·2	20·3	9.553·7	0·671	2·649		13·58	190·06	35.123·1	6·994	6·848	245.651·0	4·330	41.914·4	203.736·6	60
5	13·0	20·6	9.517·5	0·674	3·323		13·84	238·66	44.104·4	6·017	7·190	265.376·2	4·830	46.754·4	218.621·8	75
6	12·9	20·8	9.499·6	0·677	4·000		14·05	287·48	53.126·3	5·055	7·227	268.553·4	5·000	48.400·0	220.153·4	90
7	12·9	20·8	9.499·6	0·677	4·677		14·05	336·29	62.146·4	3·998	7·221	248.461·3	4·830	46.754·4	201.706·9	105
8	13·0	20·6	8.517·5	0·674	5·351		13·84	384·89	71.127·7	3·021	7·042	214.876·8	4·330	41.914·4	172.962·4	120
9	13·2	20·3	9.553·7	0·671	6·022		13·58	433·23	80.060·9	2·110	6·701	168.928·5	3·536	34.228·5	134.700·0	135
10	13·4	19·9	9.589·4	0·668	6·690		13·26	481·25	88.935·0	1·290	6·220	114.726·2	2·500	24.200·0	90.526·2	150
11	14·0	19·1	9.698·9	0·661	7·351		12·59	528·60	97.685·3	0·584	5·622	56.852·6	1·294	12.525·9	44.326·7	165
12	15·0	17·9	9.882·2	0·649	8·000		11·58	574·95	106.250·8	—	5·000	—	—	-	—	180
							157·81									

Table VII.

0	—	—	—	—	—	Unvarying for each phase = 49·27 m²	—	—	—	—	—	—	—	—	—	—
1	16·8	22·5	6.188·1	1·191	1·191		26·80	76·07	11.410·5	10·437	8·325	-119.091·4	1·269	13.327·5	105.763·9	15
2	15·2	24·9	6.069·5	1·213	2·404		30·20	155·54	23.331·0	9·394	8·910	219.171·4	2·452	25.746·0	193.425·4	30
3	14·4	26·3	5.853·7	1·262	3·666		33·19	238·00	35.700·0	8·277	9·284	295.488·9	3·468	36.414·0	259.074·9	45
4	14·1	26·9	5.810·8	1·271	4·937		34·66	321·93	48.289·5	7·137	9·455	344.642·2	4·247	44.593·5	300.048·7	60
	13·8	27·4	5.814·4													
5	13·6	27·9	5.786·5	1·280	6·217		35·71	406·91	61.036·5	5·986	9·423	365.364·5	4·737	49.738·5	315.626·0	75
6	13·4	28·2	5.757·2	1·290	7·507		36·38	492·56	73.884·0	4·861	9·190	359.150·1	4·904	51.492·0	307.658·1	90
7	13·4	28·2	5.757·0	1·290	8·797		36·38	578·21	86.731·5	3·787	8·780	328.452·2	4·737	49.738·5	278.713·7	105
8	13·6	27·9	5.792·0	1·279	10·076		35·68	663·16	99.474·0	2·786	8·213	277.134·6	4·247	44.593·5	232.541·1	120
9	13·9	27·1	5.820·0	1·269	11·345		34·30	746·73	112.009·5	1·887	7·510	211.361·9	3·468	36.414·0	174.947·9	135
10	14·4	26·3	5.901·7	1·259	12·604		33·02	829·02	124.356·0	1·112	6·694	138.283·9	2·452	25.746·0	112.537·9	150
11	15·2	24·9	6.238·5	1·209	13·813		30·01	908·30	136.245·0	0·472	5·814	64.307·6	1·269	13.327·5	50.980·1	165
12	16·8	22·5	6.240·9	1·187	15·000		26·62	984·18	147.627·0	—	4·904	—	—	—	—	180
							392·95									

Table IX.

Phase	m	x	m x	y	my		
1.	e_1 = 21·76	7·70	167·43	7·00	152·21		
	f_1 = 13·41	5·50	73·76	5·55	74·43		
2.	35·17		241·19		226·64	x_1 = 6·858	y_1 = 6·444
	e_2 = 21·75	5·60	221·84	8·80	191·46		
	f_2 = 16·45	4·82	79·29	4·60	75·67		
3.	73·37		442·32		493·77	x_2 = 6·028	y_2 = 6·727
	e_3 = 21·76	3·10	67·44	9·95	216·47		
	f_3 = 18·23	4·50	82·06	3·60	65·63		
4.	113·36		591·82		771·87	x_3 = 5·221	y_3 = 6·846
	e_4 = 21·76	0·45	9·79	10·40	226·26		
	f_4 = 19·44	4·30	83·59	2·60	50·54		
5.	154·56		685·20		1.048·67	x_4 = 4·433	y_4 = 6·785
	e_5 = 21·75	— 2·25	— 48·95	10·20	221·91		
	f_5 = 20·66	4·20	86·77	1·50	30·99		
6.	196·97		723·02		1.301·57	x_5 = 3·671	y_5 = 6·671
	e_6 = 21·76	— 4·80	— 104·43	9·20	200·16		
	f_6 = 22·85	4·15	94·83	0·50	11·42		
7.	241·58		713·42		1.513·15	x_6 = 2·954	y_6 = 6·263
	e_7 = 21·76	— 7·00	— 152·29	7·65	166·43		
	f_7 = 22·85	4·15	94·83	— 0·50	— 11·42		
8	286·19		655·96		1.691·00	x_7 = 2·292	y_7 = 5·908
	e_8 = 21·76	— 8·80	— 191·45	5·55	120·75		
	f_8 = 20·66	4·20	86·77	— 1·50	— 30·99		
9.	328·61		551·28		1.742·74	x_8 = 1·678	y_8 = 5·303
	e_9 = 21·75	— 9·90	— 215·39	3·10	67·45		
	f_9 = 19·44	4·30	83·59	— 2·60	— 50·54		
10.	369·80		419·48		1.759·65	x_9 = 1·134	y_9 = 4·758
	e_{10} = 21·76	— 10·40	— 226·26	0·45	9·79		
	f_{10} = 18·13	4·50	82·06	— 3·60	— 65·63		
11.	409·69		275·28		1.703·81	x_{10} = 0·672	y_{10} = 4·159
	e_{11} = 21·76	— 10·15	— 220·82	— 2·25	— 48·95		
	f_{11} = 16·23	4·82	79·29	— 4·60	— 75·67		
12.	447·68		133·75		1.579·19	x_{11} = 0·299	y_{11} = 3·527
	e_{12} = 21·75	— 9·30	— 202·30	— 4·75	— 103·35		
	f_{12} = 13·41	5·50	73·76	— 5·55	— 74·43		
	482·84	—	—	—	1.401·41	x_{12} = 0	y

Table II.

Phase	Px — Qq. sin α	—Z_1 z_1 sin α	Px—Qq. sin α —Z_1 z_1 sin α	Z_2 z_2 sin (90 + α)	Px—Qq. sin α —Z_1 z_1 sin α —Z_2 z_2 sin (90 + α)
0	—	—	—	— 2.680·0	— 2.680·0
1	11.056·6	— 8.068·6	+ 2.988·0	— 2.588·7	+ 399·3
2	20.084·9	—15.740·0	+ 4.344·9	— 2.321·0	+ 2.023·9
3	26.877·3	22.302·3	+ 4.575·0	— 1.895·0	+ 2.680·0
4	30.560·7	27.314·6	+ 3.246·1	— 1.340·0	+ 1.906·1
5	31.904·8	30.465·4	+ 1.439·4	— 693·6	+ 745·8
6	31.176·2	31.540·0	— 363·8	— —	— 363·8
7	28.344·2	30.465·4	— 2.121·2	+ 693·6	— 1.427·6
8	23.466·3	27.314·6	— 4.048·3	+ 1.340·0	— 2.708·3
9	17.728·0	22.302·3	— 4.574·3	+ 1.895·0	— 2.679·0
0	11.162·0	15.740·0	— 4.578·0	+ 2·321·0	— 2.257·0
11	5.392·2	8·068·6	— 2.676·4	+ 2.588·7	— 87·7
2	—	—	—	+ 2.680·0	+ 2.680·0

Table VI.

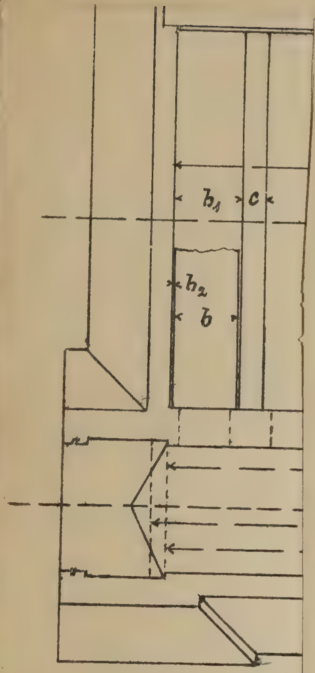
Phase	Px — Qq. sin α	—Z_1 z_1 sin α	Px — Qq. sin α — Z_1 z_1 sin α	Z_2 z_2 sin (90 + α)	Px — Qq. sin α — Z_1 z_1 sin α —Z_2 z_2 sin (90 + α)
0	—	—	-	—11.275·2	—11.275·2
1	69.017·7	— 56.349·8	+12.667·9	—10.291·1	+ 1.776·8
2	127.903·7	—108.859·0	+19.044·7	— 9.764·7	+ 9.280·0
3	173.195·5	—153.947·8	+19.247·7	— 7.972·8	+11.274·9
4	203.736·6	—188.550.3	+15.186·3	— 5.637·6	+ 9.548·7
5	218.621·8	—210.300·3	+ 8·321·5	— 2.918·2	+ 5.403·3
6	220.153·4	—217.718·0	+ 2.435·4	— —	+ 2.435·4
7	201.706·9	—210.300·3	— 8.593·4	+ 2.918·2	— 5.675·2
8	172.962·4	—188.550·3	—15.587·9	+ 5.637·6	— 9.950·3
9	134.700·0	—153·947·7	—19.247·7	+ 7.972·8	—11.274·9
10	90.526·2	—108.859·0	—18.333·8	+ 9.764·7	— 8.569·1
11	44.326·7	— 56.349·8	—12.023·1	+10.891·1	— 1.132·0
12	—	—	—	+11.275·2	+11·275·2

Table IV.

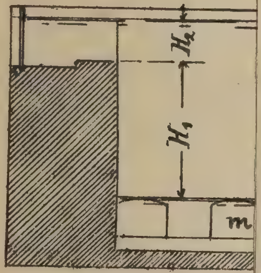
	—	—	—	— 9.509·4	— 9.509·4
	4.417·7	—24.215·6	+10.202·1	— 9.185·4	+ 1.016·7
	.235·6	46.780·7	+15.454·9	— 8.235·4	+ 7.219·5
	2.391·9	66.158·2	+16.233·7	— 6.784·0	+ 9.449·7
	93.896·1	81.027·0	+12.869·1	— 4.754·7	+ 8.114·4
	96.285·8	90.373·7	+ 5.912·1	— 2.461·2	+ 3,450·9
	[illegible]	93.561·4	— 577·8	— —	— 577·8
7	82.642·5	90 373·7	— 7.731·2	+ 2.461·2	— 5,270·0
	68.179·7	81.027·0	—13.847·3	+ 4.754·7	— 9.092·6
	49.924·5	66.158·2	—16.233·7	+ 6.784·0	— 9.449·7
	1.372·2	46.780·7	—15.408·5	+ 8.235·4	— 7.173·1
	4 376·2	24.215·6	— 9.839·4	+ 9.185·4	— 654·0
	—	—		+ 9.509·4	+ 9.509·4

Table VIII.

0	—	—	—	—24.640·2	—24.640·2
1	105.763·9	— 79.431·6	+26.332·3	—23.800·7	+ 2.531·6
2	193.425·4	—153.449·5	+39 975·9	—21.339·2	+18.636·7
3	259.074·9	—217.011·4	+42.063·5	—17.423·3	+24.640·2
4	300.048·7	—265.783·7	+34.265·0	—12.320·1	+21.944·9
5	315.626·0	—296.443·0	+19.183·0	— 6.337·4	+12.845·6
6	307.658·1	—306.899·0	+ 759·1	— —	+ 759·1
7	278.713·7	—296.443·0	—17.729·3	+ 6.337·4	—11.391·9
8	232 541·1	—265.783·7	—33.242·6	+12.320·1	—20.922·5
9	174.947·9	—217.011·4	—42.063·5	+17.423·3	—24.640·2
10	112.537·9	—153.449·5	—40.911·6	+21.339·2	—19.572·4
11	50.980·1	— 79.431·6	—28.451·5	+23.800·7	— 4.650·8
12	—	—	—	+24.640·2	+24.640·2

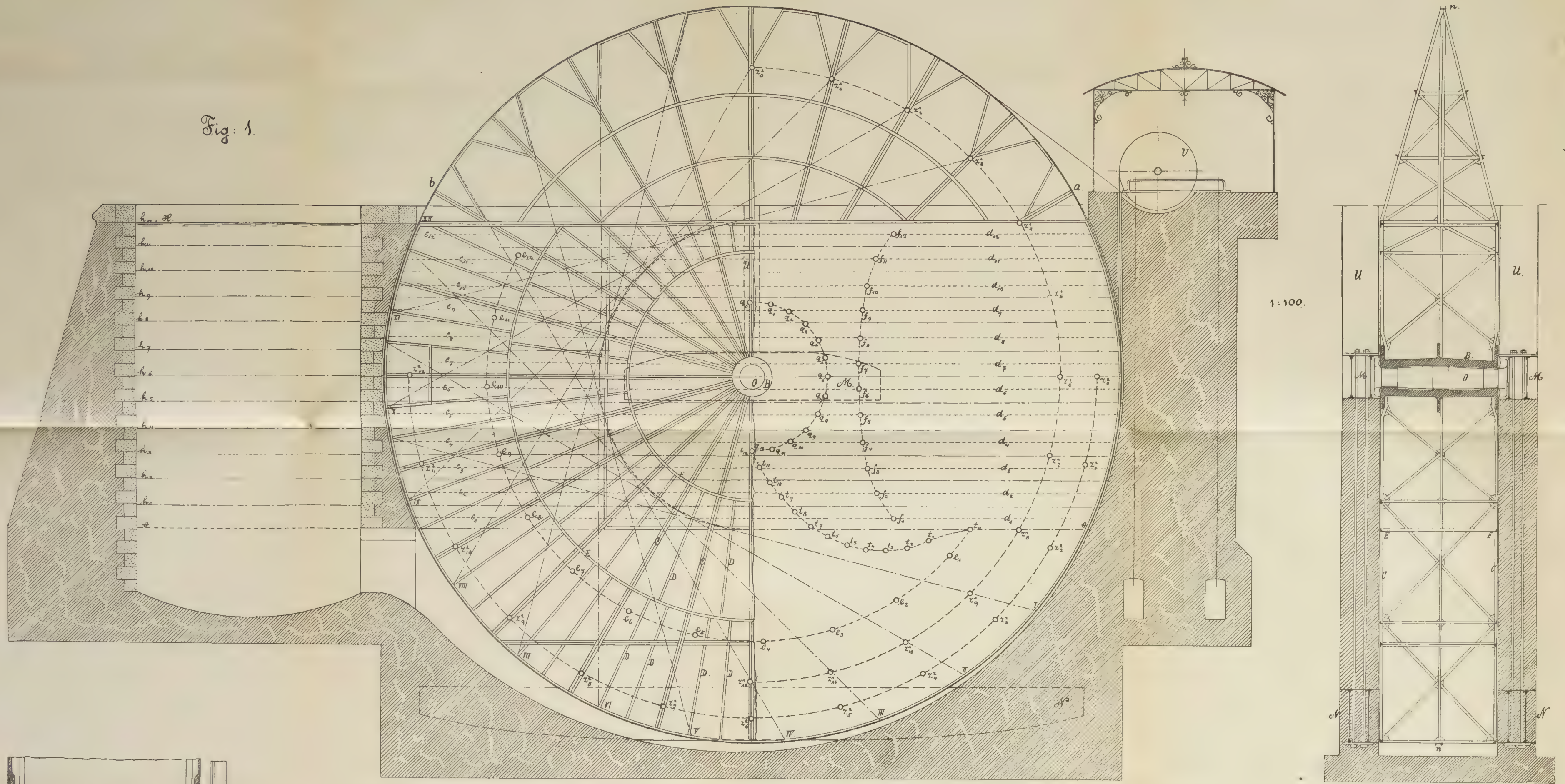


b_1
c
b_2
b



H_2
H_1
m

Fig: 1.



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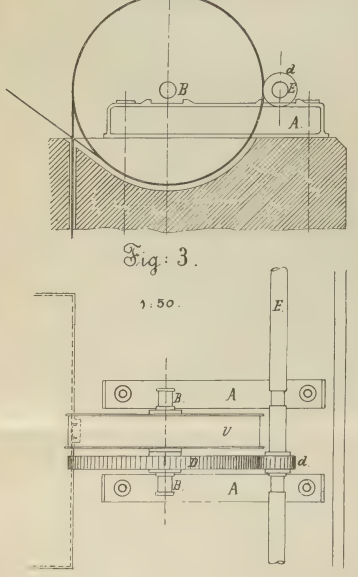

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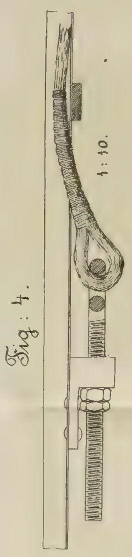

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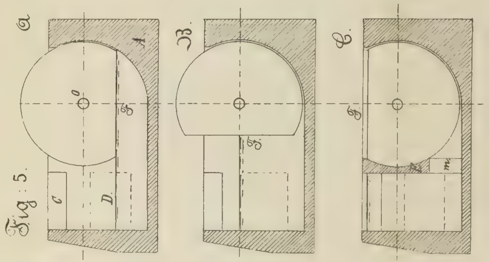

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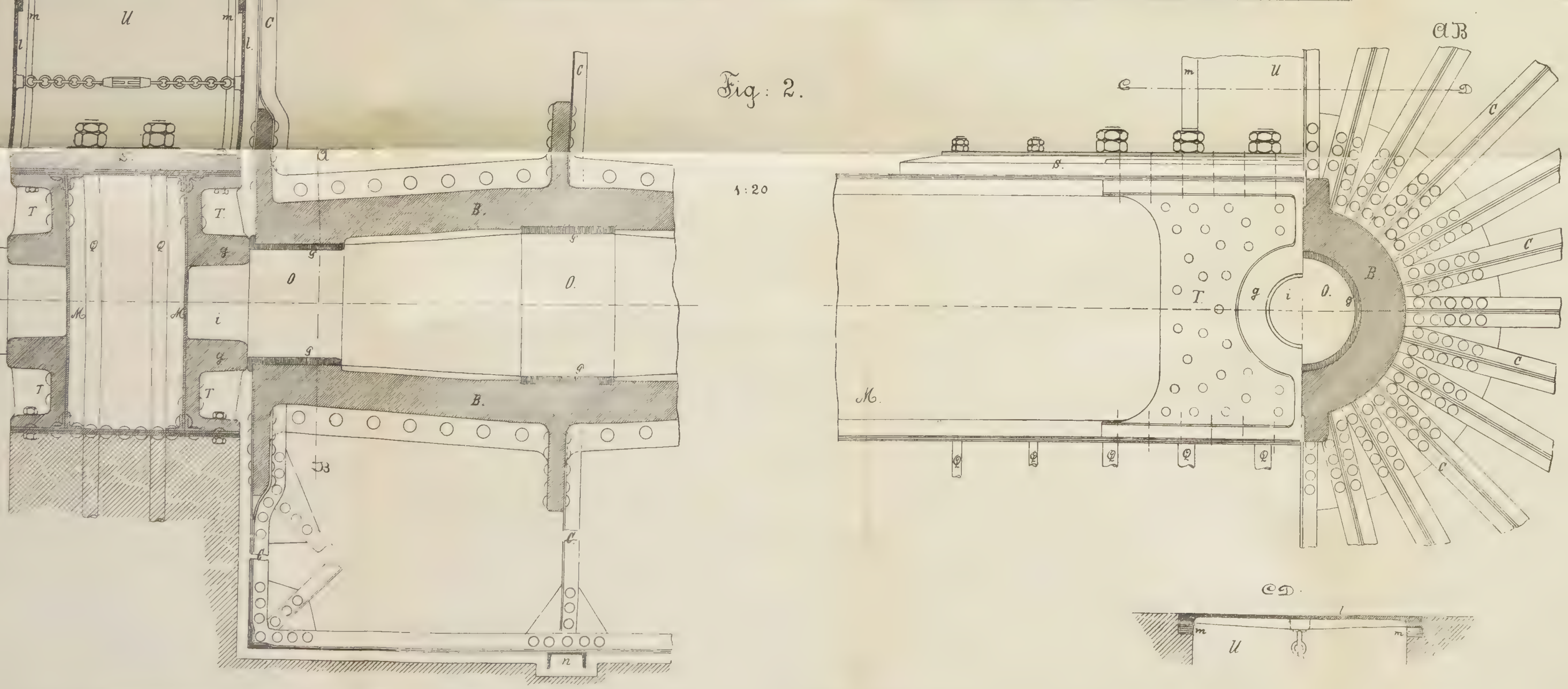

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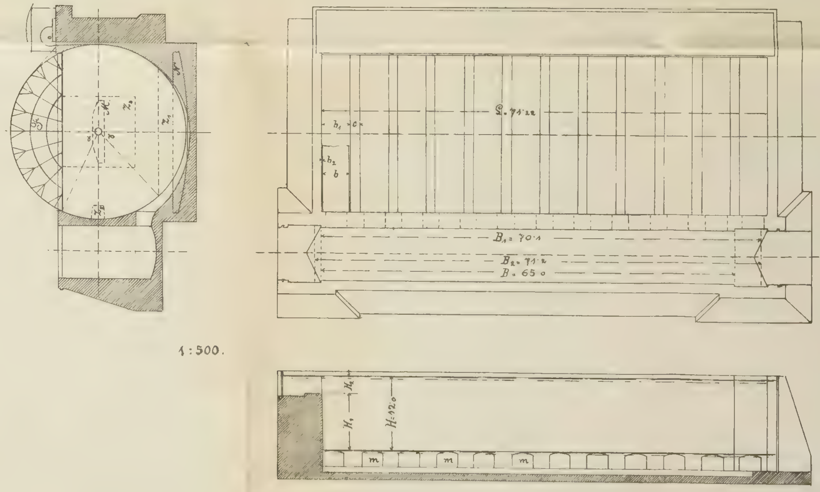

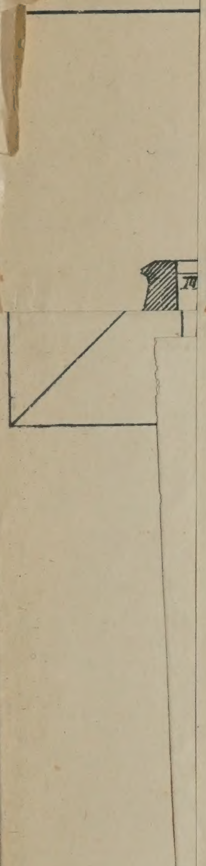
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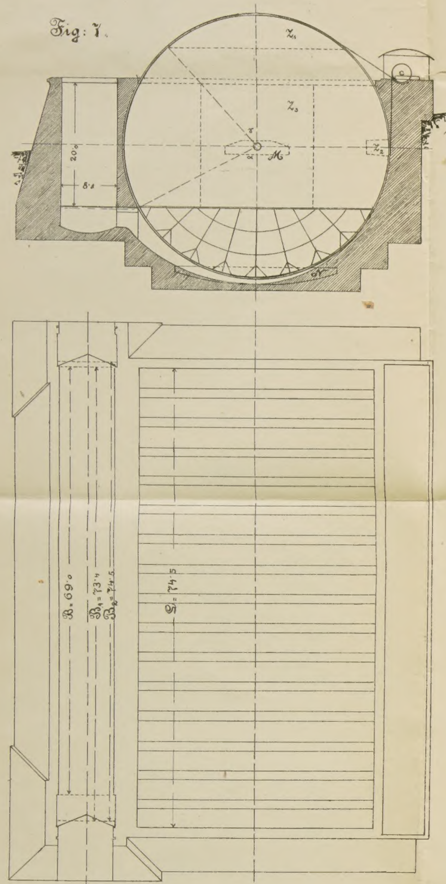

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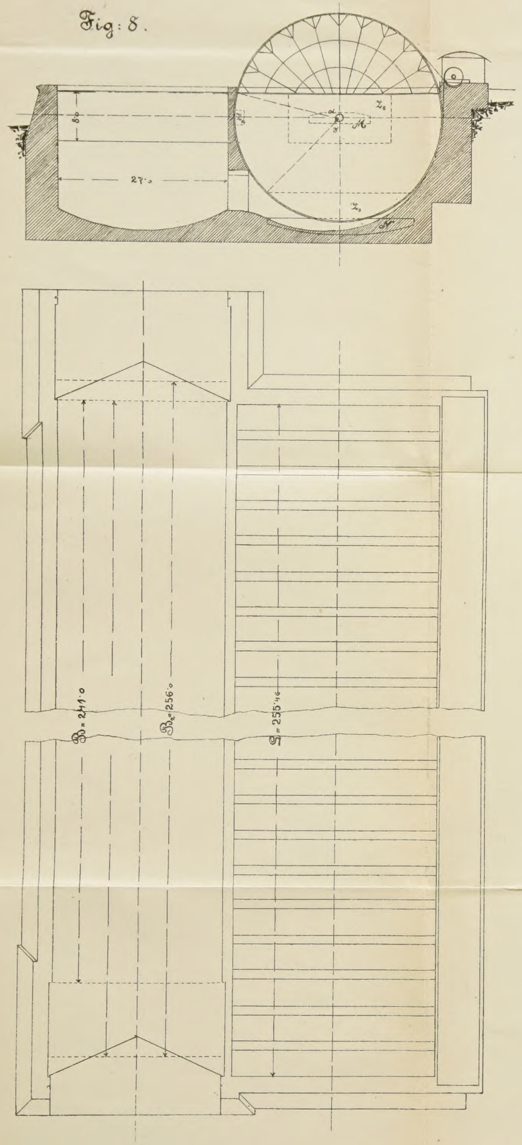

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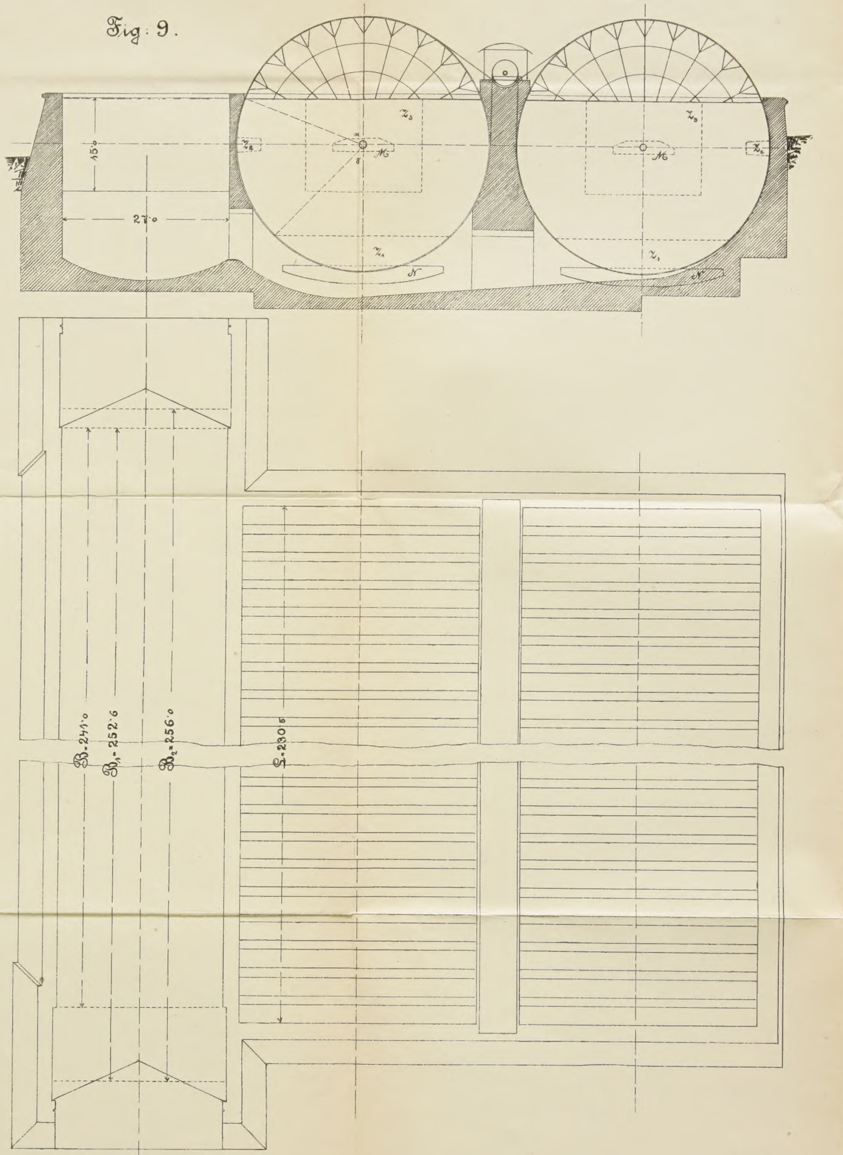

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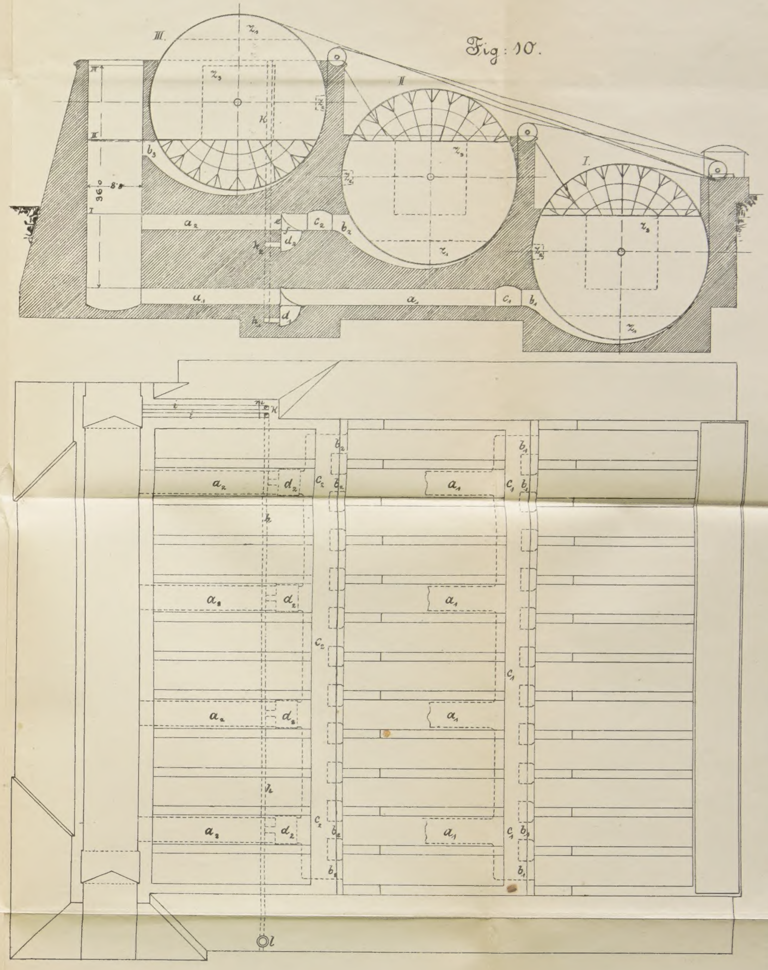

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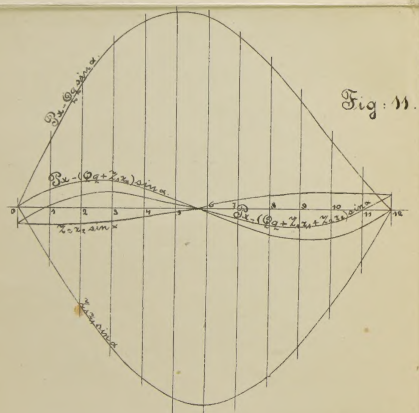

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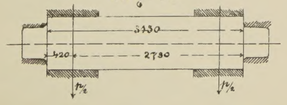

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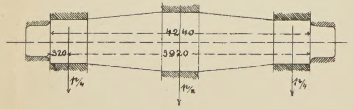

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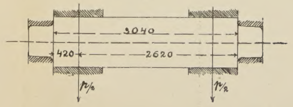

Fig: 15.